US009193547B2

(12) **United States Patent**
Suzuki

(10) **Patent No.: US 9,193,547 B2**
(45) **Date of Patent: Nov. 24, 2015**

(54) **SHEET CONVEYER DEVICE AND IMAGE FORMING APPARATUS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 69 days.

(21) Appl. No.: **13/953,829**

(22) Filed: **Jul. 30, 2013**

(65) **Prior Publication Data**

US 2014/0037350 A1 Feb. 6, 2014

(30) **Foreign Application Priority Data**

Aug. 3, 2012 (JP) 2012-172596

(51) **Int. Cl.**
G03G 15/00 (2006.01)
B65H 7/02 (2006.01)

(52) **U.S. Cl.**
CPC ***B65H 7/02*** (2013.01); ***G03G 15/6514*** (2013.01); ***G03G 15/70*** (2013.01); *B65H 2407/21* (2013.01); *B65H 2511/11* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... G03G 15/00; G03G 15/6514; G03G 15/70; G03G 2215/0141; B65H 7/00; B65H 7/06; B65H 7/02; B65H 2407/21; B65H 2511/11; B65H 2511/51; B65H 2513/512; B65H 2513/514; B65H 2513/53; B65H 2701/1311; B65H 2701/1313; B65H 2801/06
USPC 399/21, 23, 392, 16
See application file for complete search history.

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Notification of First Office Action dated Jun. 2, 2015 received from the Chinese Patent Office in related application CN 201310334353.0 together with an English language translation.

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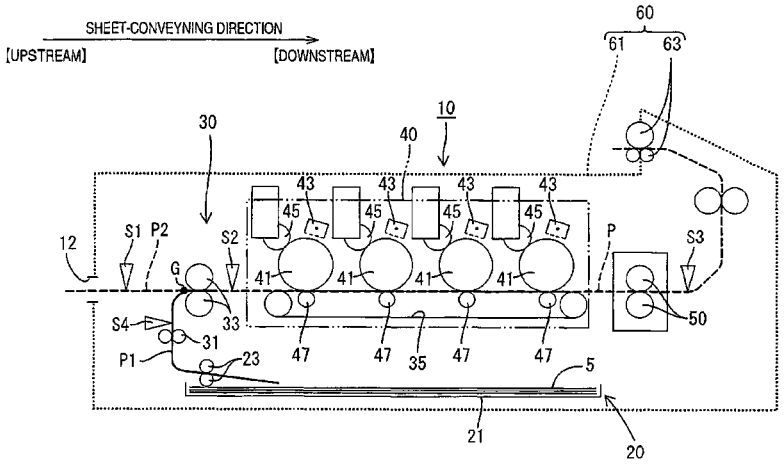
(57) **ABSTRACT**

A sheet conveyer, including a manual-feed conveyer path; a first sensor to detect presence of the sheet inserted in the manual-feed conveyer path; an upstream-side conveyer and a downstream-side conveyer to convey the sheet toward a downstream side; a second sensor to detect presence of the sheet in a downstream position with respect to the upstream-side conveyer, the second sensor being switchable between a presence-detectable state and an absence-detectable state; and a controller is provided. The controller measures presence-detecting duration of the sheet by the second sensor and controls the downstream-side conveyer to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched to the absence-detectable state, and if a difference between a value calculated based on the measured presence-detecting duration and a reference value obtained based on a reference sheet length is smaller than a predetermined threshold.

26 Claims, 12 Drawing Sheets



(52) **U.S. Cl.**
CPC *B65H2511/51* (2013.01); *B65H 2513/512* (2013.01); *B65H 2513/514* (2013.01); *B65H 2513/53* (2013.01); *B65H 2701/1311* (2013.01); *B65H 2701/1313* (2013.01); *B65H 2801/06* (2013.01); *G03G 2215/0141* (2013.01)

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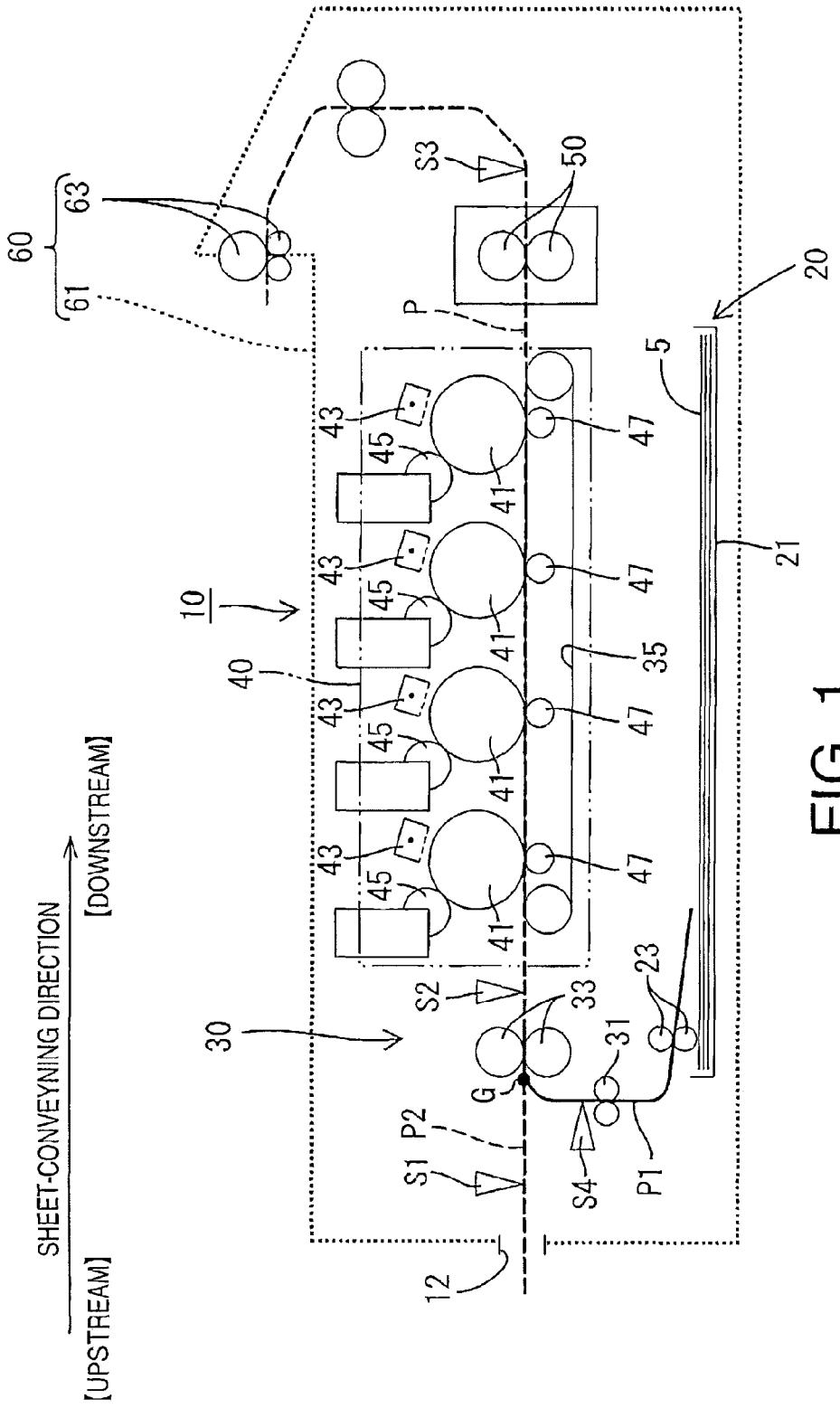
SHEET-CONVEYING DIRECTION
[UPSTREAM]
[DOWNSTREAM]
60
63
61
S3
50
P
20
5
21
10
40
43
45
41
47
35
30
S2
33
23
31
G
S1
P2
S4
P1
12

FIG. 1

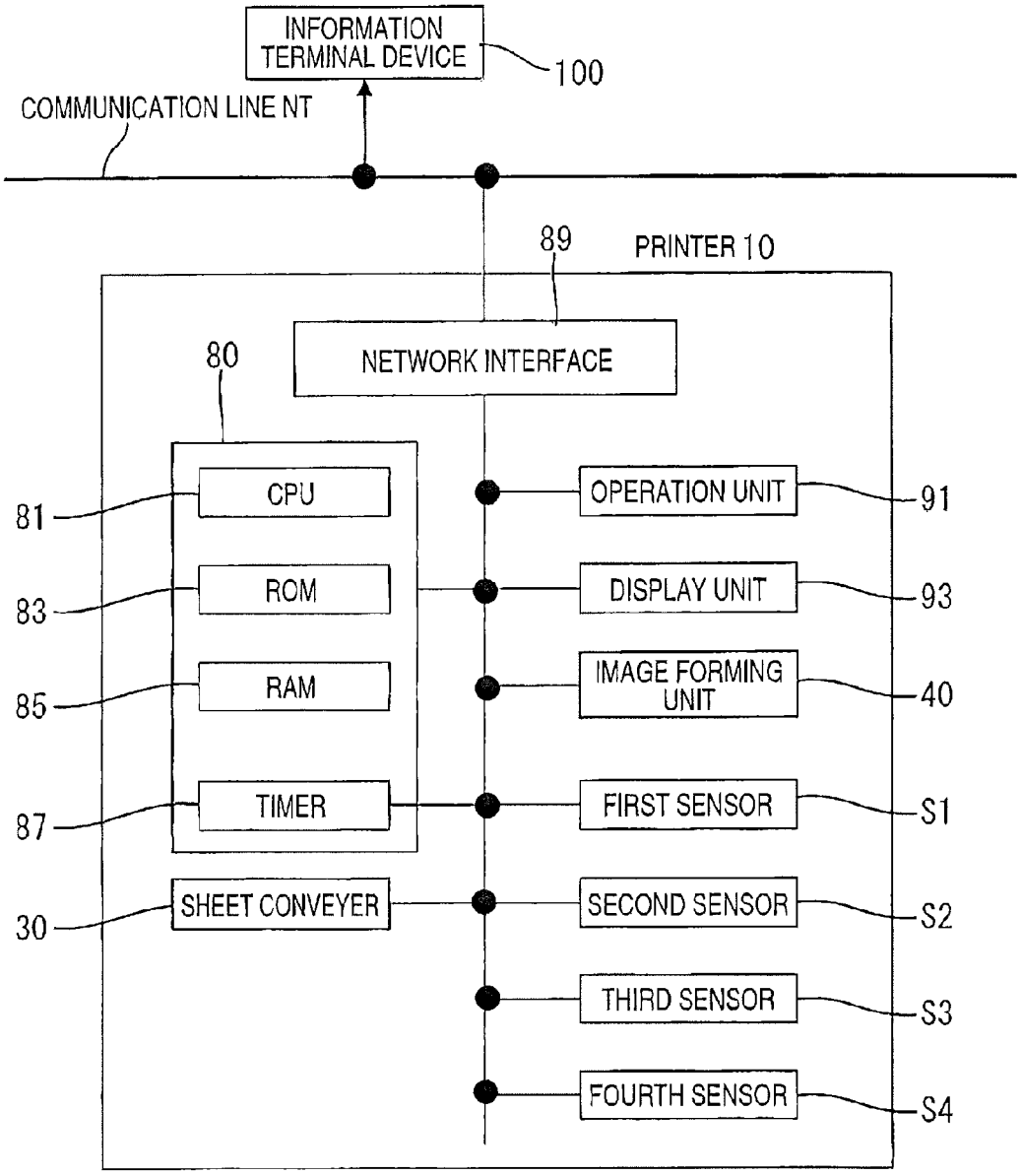
INFORMATION TERMINAL DEVICE
100
COMMUNICATION LINE NT
89
PRINTER 10
80
NETWORK INTERFACE
CPU
81
ROM
83
RAM
85
TIMER
87
SHEET CONVEYER
30
OPERATION UNIT
91
DISPLAY UNIT
93
IMAGE FORMING UNIT
40
FIRST SENSOR
S1
SECOND SENSOR
S2
THIRD SENSOR
S3
FOURTH SENSOR
S4

FIG. 2

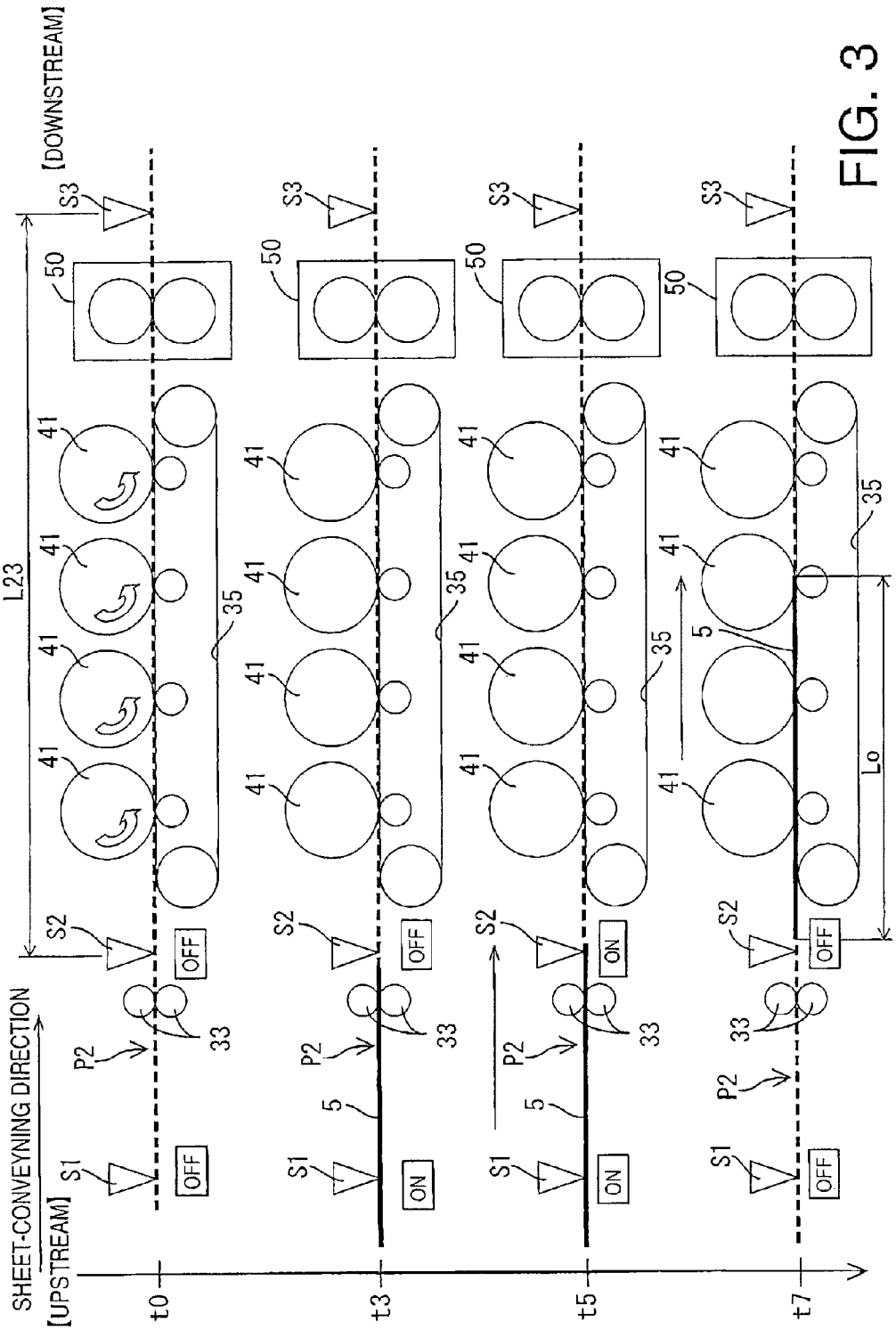
SHEET-CONVEYING DIRECTION
[UPSTREAM]
[DOWNSTREAM]
L23
Lo
S1
S2
S3
P2
OFF
ON
t0
t3
t5
t7
5
33
35
41
50

FIG. 3

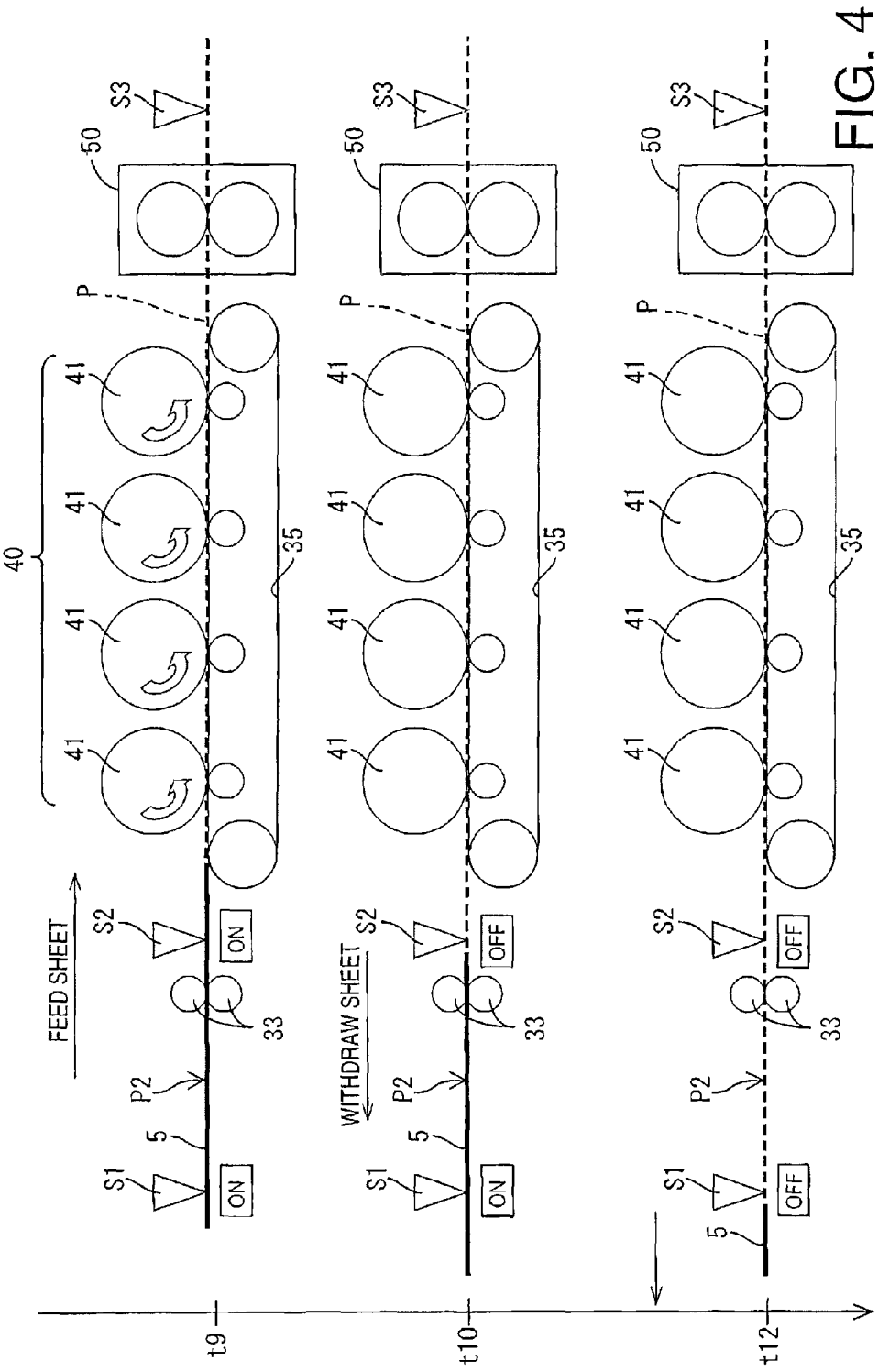
FEED SHEET
WITHDRAW SHEET
S1
S2
S3
P2
P
5
33
35
40
41
50
ON
OFF
t9
t10
t12

FIG. 4

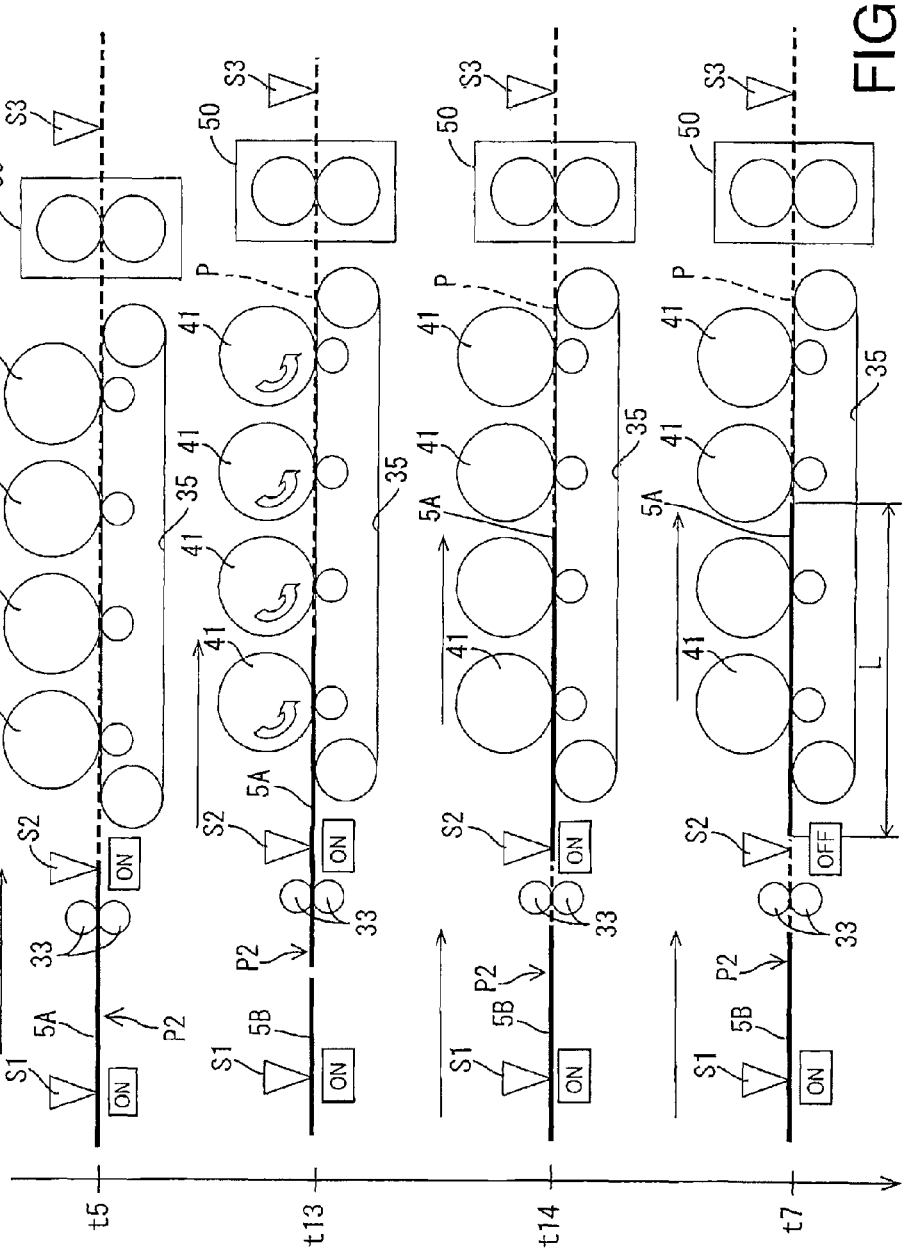

FIG. 5

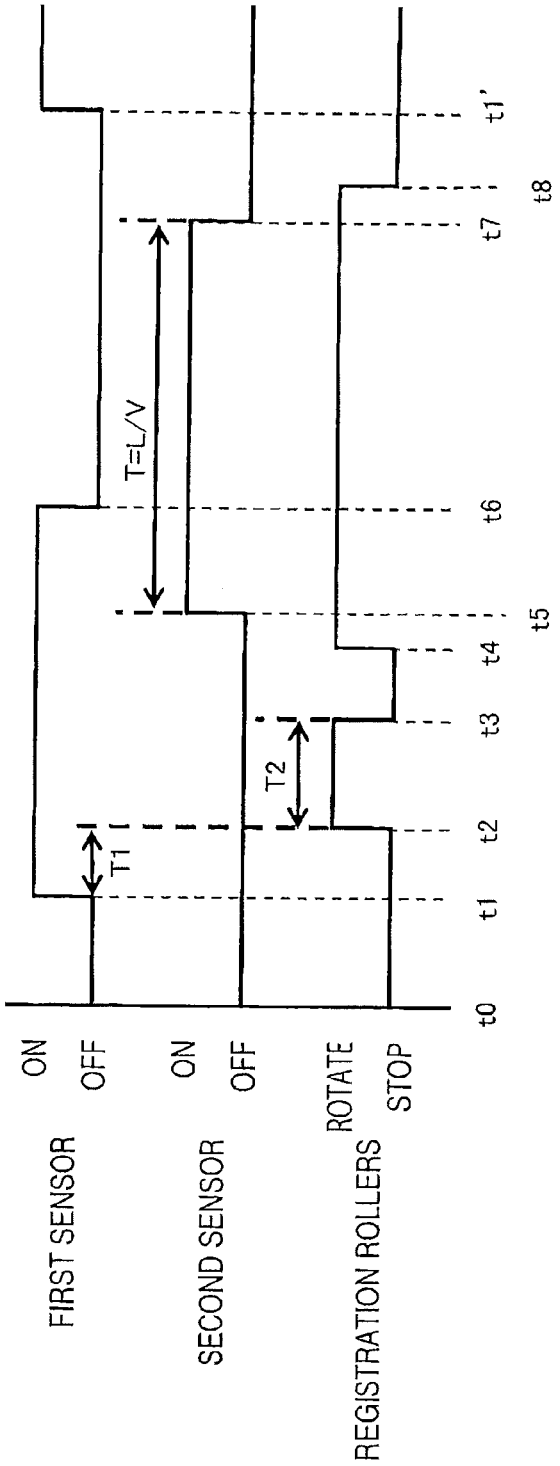
t0
t1
t2
t3
t4
t5
t6
t7
t8
t1'
T1
T2
T=L/V
ON
OFF
ON
OFF
ROTATE
STOP
FIRST SENSOR
SECOND SENSOR
REGISTRATION ROLLERS

FIG. 6

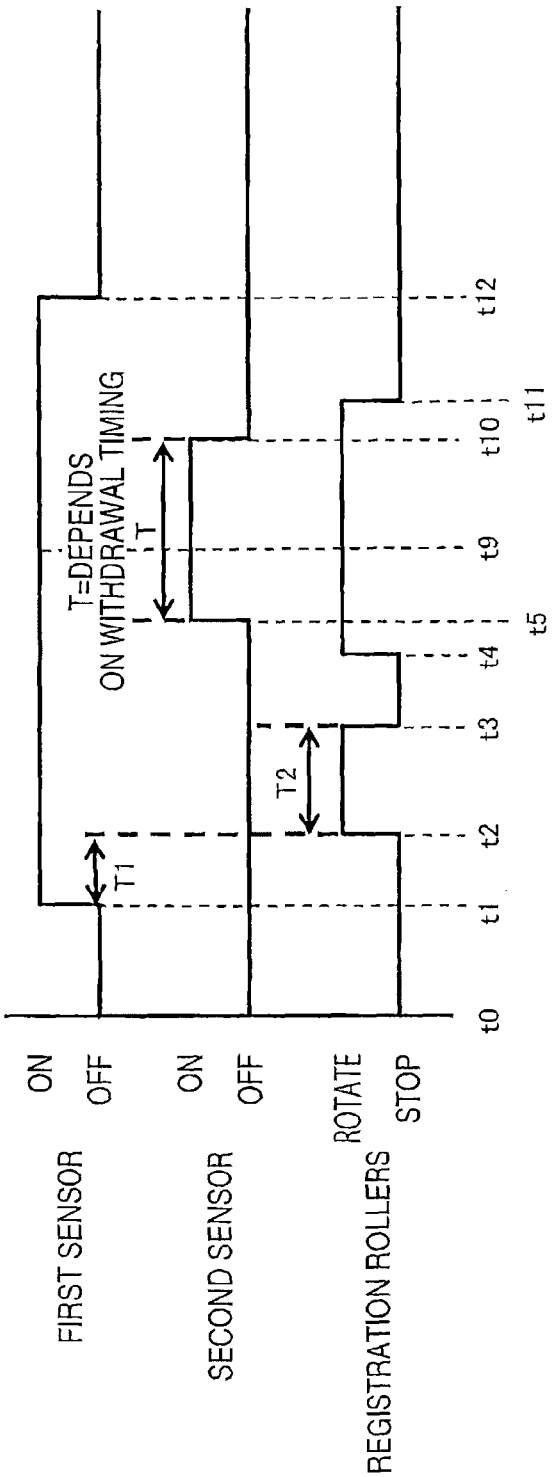
FIRST SENSOR
ON
OFF
SECOND SENSOR
ON
OFF
REGISTRATION ROLLERS
ROTATE
STOP
T1
T2
T
T=DEPENDS ON WITHDRAWAL TIMING
t0
t1
t2
t3
t4
t5
t9
t10
t11
t12

FIG. 7

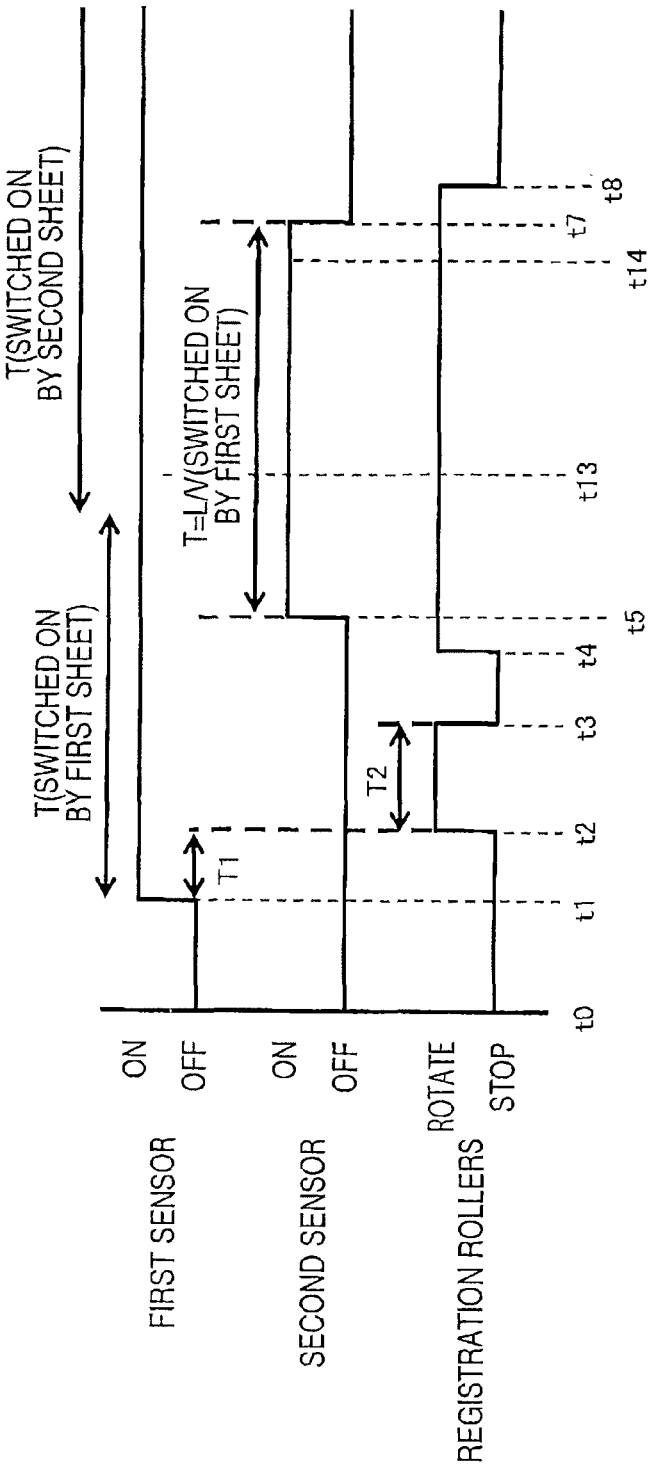
T(SWITCHED ON BY SECOND SHEET)
T(SWITCHED ON BY FIRST SHEET)
T=L/V(SWITCHED ON BY FIRST SHEET)
T1
T2
t0
t1
t2
t3
t4
t5
t13
t7
t8
t14
ON
OFF
ON
OFF
ROTATE
STOP
FIRST SENSOR
SECOND SENSOR
REGISTRATION ROLLERS

FIG. 8

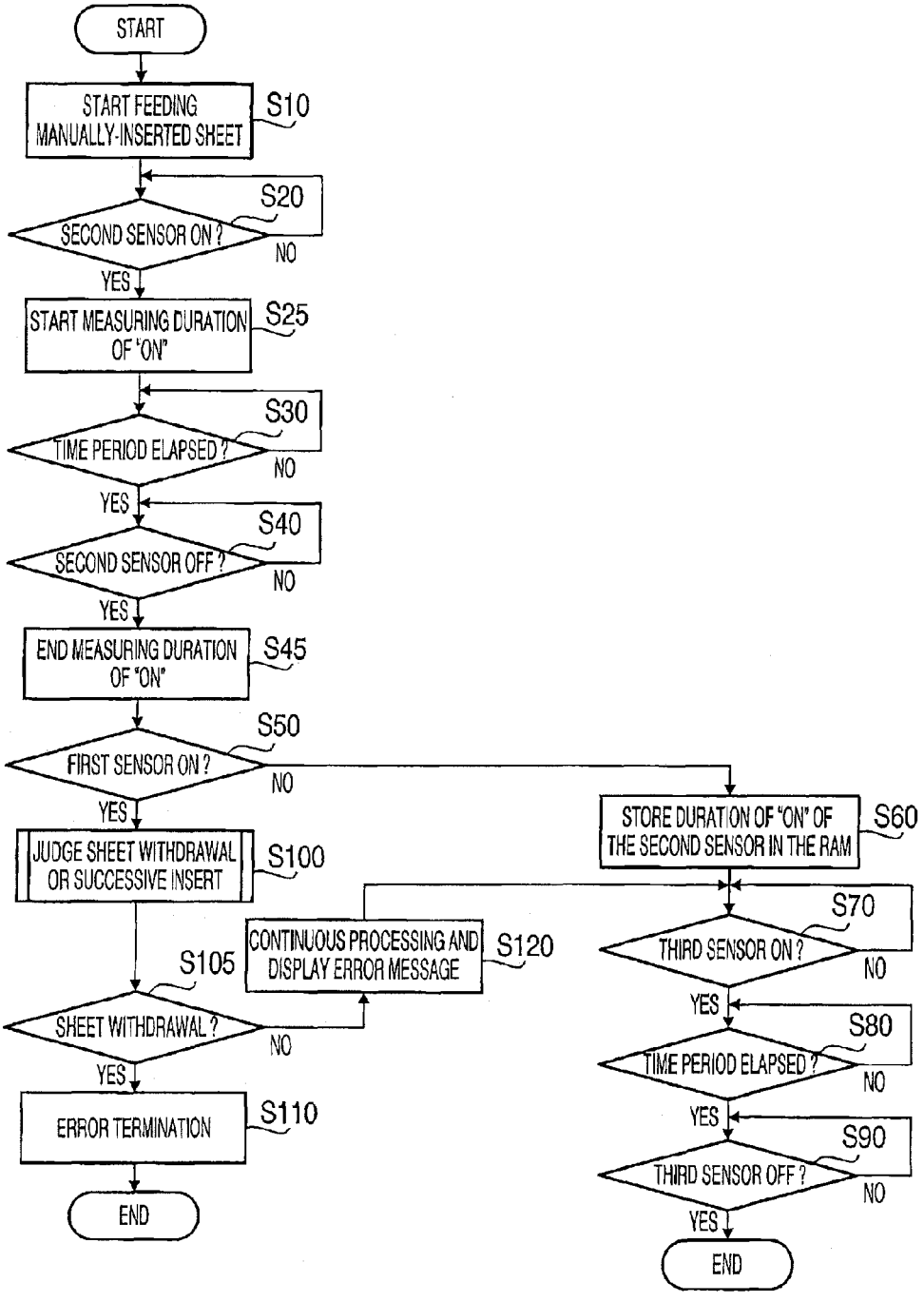
START
START FEEDING MANUALLY-INSERTED SHEET
S10
SECOND SENSOR ON ?
S20
NO
YES
START MEASURING DURATION OF "ON"
S25
TIME PERIOD ELAPSED ?
S30
NO
YES
SECOND SENSOR OFF ?
S40
NO
YES
END MEASURING DURATION OF "ON"
S45
FIRST SENSOR ON ?
S50
NO
YES
JUDGE SHEET WITHDRAWAL OR SUCCESSIVE INSERT
S100
SHEET WITHDRAWAL ?
S105
NO
YES
CONTINUOUS PROCESSING AND DISPLAY ERROR MESSAGE
S120
ERROR TERMINATION
S110
END
STORE DURATION OF "ON" OF THE SECOND SENSOR IN THE RAM
S60
THIRD SENSOR ON ?
S70
NO
YES
TIME PERIOD ELAPSED ?
S80
NO
YES
THIRD SENSOR OFF ?
S90
NO
YES
END

FIG. 9

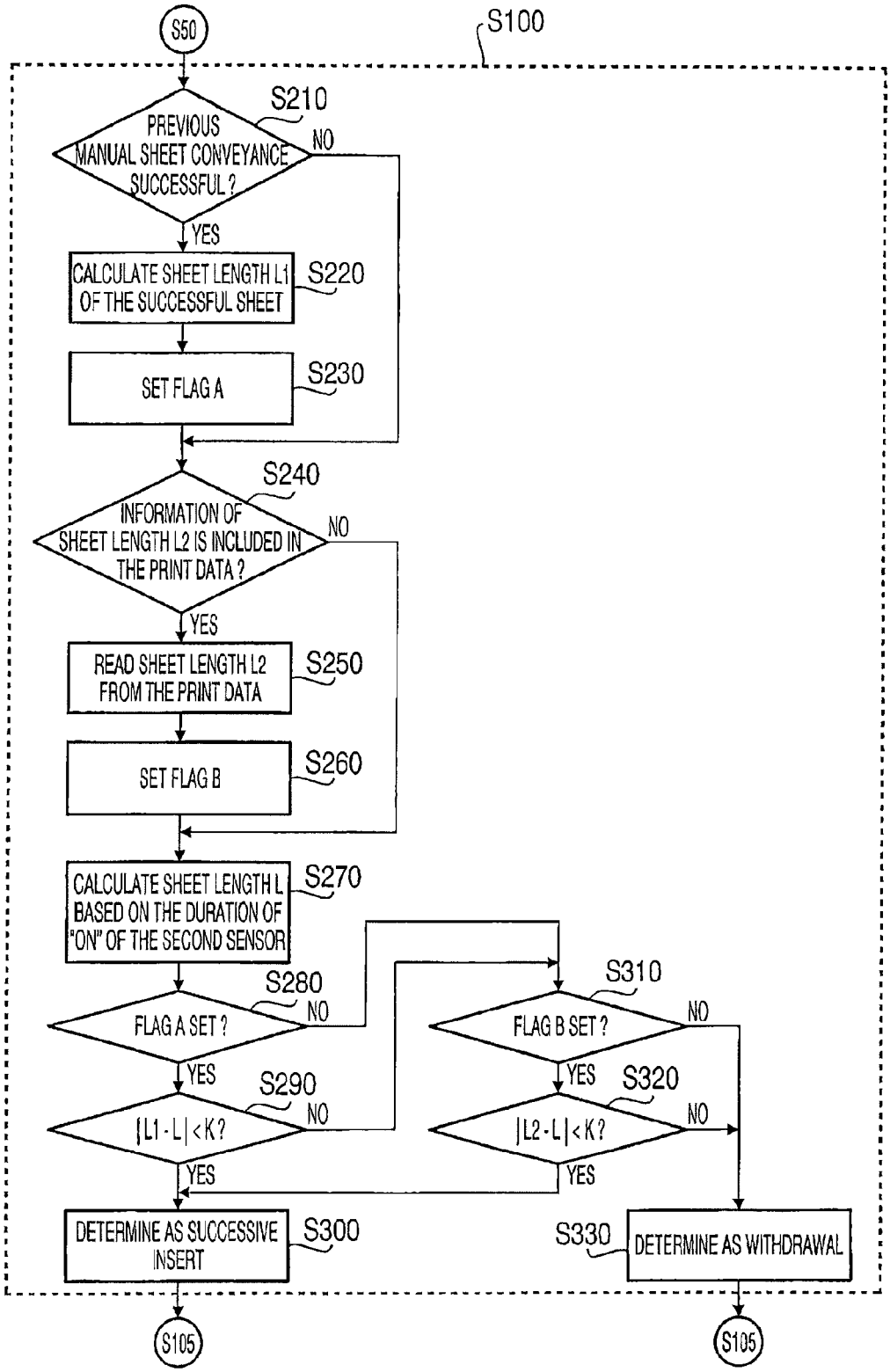
S50
S100
S210
PREVIOUS MANUAL SHEET CONVEYANCE SUCCESSFUL ?
NO
YES
CALCULATE SHEET LENGTH L1 OF THE SUCCESSFUL SHEET
S220
SET FLAG A
S230
S240
INFORMATION OF SHEET LENGTH L2 IS INCLUDED IN THE PRINT DATA ?
NO
YES
READ SHEET LENGTH L2 FROM THE PRINT DATA
S250
SET FLAG B
S260
CALCULATE SHEET LENGTH L BASED ON THE DURATION OF "ON" OF THE SECOND SENSOR
S270
S280
FLAG A SET ?
NO
YES
S290
|L1 - L| < K ?
NO
YES
S310
FLAG B SET ?
NO
YES
S320
|L2 - L| < K ?
NO
YES
DETERMINE AS SUCCESSIVE INSERT
S300
S330
DETERMINE AS WITHDRAWAL
S105
S105

FIG.10

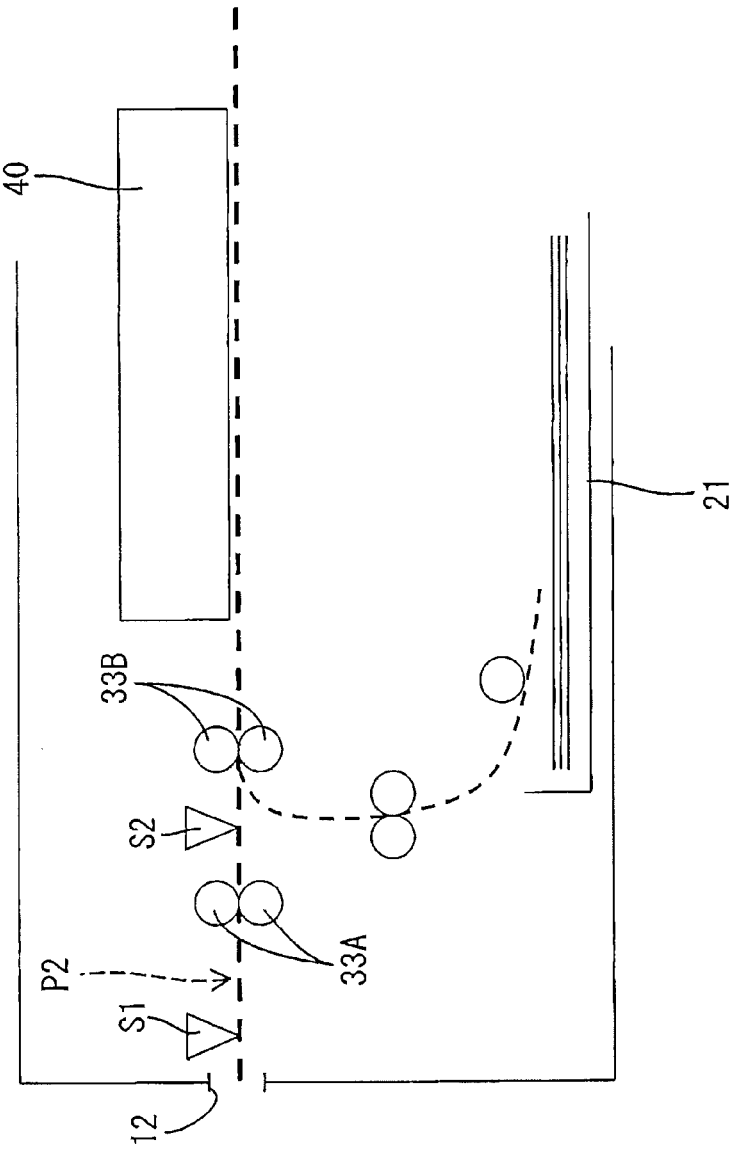

FIG.11

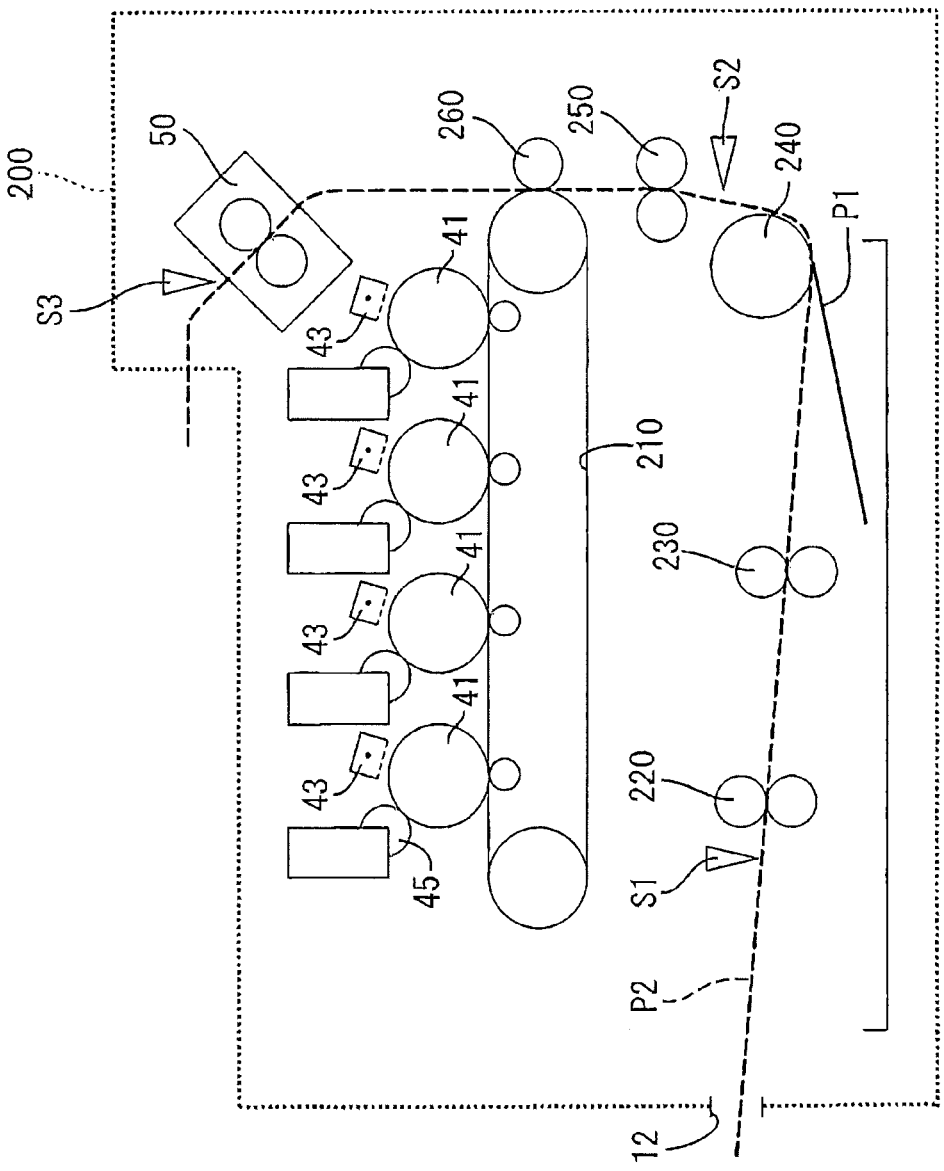

FIG.12

SHEET CONVEYER DEVICE AND IMAGE FORMING APPARATUS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2012-172596, filed on Aug. 3, 2012, the entire subject matter of which is incorporated herein by reference.

BACKGROUND

1. Technical Field

An aspect of the present invention relates to a technique to convey sheets via a sheet conveying path provided for manually inserted sheets.

2. Related Art

A printing apparatus with sensors to detect a manually-inserted sheet in a sheet conveying path is known. In the printing apparatus, when a manual-insert sensor is switched on to indicate presence of a manually-inserted sheet, but an ejection sensor is not switched on to indicate presence of the sheet within a predetermined time period, it may be determined that the manually-inserted sheet is jammed in the sheet conveying path. While the manually-inserted sheet is jammed and not conveyed along the sheet conveying path, a printing operation with the manually-inserted sheet may be stopped.

Meanwhile, if the manual-insert sensor is switched on by a manually-inserted sheet, and if the manual-insert sensor is not switched off by the same manually-inserted sheet within a predetermined time period corresponding to a length of the sheet, it may be recognized that the manually-inserted sheet is inserted to reach a detective range of the manual-insert sensor while a preceding sheet is still in the detective range of the manual-insert sensor. In this regard, a tail end of the preceding sheet and a leading end of the following sheet may be undesirably in proximity to each other along the sheet conveying path. Therefore, although it may be recognized as a user's sheet-inserting error, no sheet jam is in fact occurring. Based on the recognition that the manually inserted sheets are serially conveyed without being jammed along the sheet conveying path, the printing operation with the successively inserted sheets may be continued. In other words, the printing operation may not necessary be stopped or aborted.

On the other hand, a user once inserting a sheet through a manual sheet inlet may take out the sheet from the sheet conveying path in a short time period. In such a case, while the once-inserted sheet is no longer conveyed in the sheet conveying path, it may be preferable that the printing operation is stopped. In other words, the printing operation may be stopped when an assumption that the once-inserted sheet is withdrawn is made.

SUMMARY

However, while the behavior of the manual-insert sensor may not clearly indicate if it is the manually-inserted sheet reaching the detective range of the manual-insert sensor while the preceding sheet still remains in the detective range, or if it is the once-inserted sheet being immediately withdrawn, it is possible that the printing operation may be unnecessarily stopped based on the assumption that the once-inserted sheet is withdrawn, even though it is in fact the manually-inserted sheet successively reaching the detective range of the manual-insert sensor while the preceding sheet still remains in the detective range. Therefore, simply stopping the printing operation may cause inconvenience on the user.

In view of such consideration, the present invention is advantageous in providing a technique to improve usability of the manual sheet-supplying function.

According to an aspect of the present invention, a sheet conveyer is provided. The sheet conveyer includes a manual-feed conveyer path, in which a sheet is inserted manually and conveyed along a sheet conveying direction; a first sensor arranged along the manual-feed conveyer path and configured to detect presence of the sheet inserted in the manual-feed conveyer path; an upstream-side conveyer configured to convey the sheet having passed by the first sensor toward a downstream side along the sheet conveying direction; a downstream-side conveyer configured to convey the sheet conveyed by the upstream-side conveyer further toward the downstream side along the sheet conveying direction; a second sensor arranged along the manual-feed conveyer path in a downstream position with respect to the upstream-side conveyer along the sheet conveying direction and configured to detect presence of the sheet in the downstream position with respect to the upstream-side conveyer, the second sensor being switchable between a presence-detectable state, in which the second sensor detects presence of the sheet, and an absence-detectable state, in which the second sensor detects absence of the sheet; and a controller. The controller is configured to measure presence-detecting duration, which starts when the second sensor is switched from the absence-detectable state to the presence-detectable state and ends when the second sensor is switched from the presence-detectable state to the absence-detectable state; and control the downstream-side conveyer to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between a value calculated based on the measured presence-detecting duration and a reference value obtained based on a reference sheet length of an assumed sheet along the sheet conveying direction is equal to or larger than a predetermined threshold, and to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the value calculated based on the measured presence-detecting duration and the reference value obtained based on the reference sheet length of an assumed sheet along the sheet conveying direction is smaller than the predetermined threshold.

According to another aspect of the present invention, an image forming apparatus is provided. The image forming apparatus includes a manual-feed conveyer path, in which a sheet is inserted manually and conveyed along a sheet conveying direction; a first sensor arranged along the manual-feed conveyer path and configured to detect presence of the sheet inserted in the manual-feed conveyer path; an upstream-side conveyer configured to convey the sheet having passed by the first sensor toward a downstream side along the sheet conveying direction; a downstream-side conveyer configured to convey the sheet conveyed by the upstream-side conveyer further toward the downstream side along the sheet conveying direction; an image forming unit configured to form an image on the manually inserted sheet conveyed through the manual-feed conveyer path; a second sensor arranged along the manual-feed conveyer path in a downstream position with respect to the upstream-side conveyer and on an upstream position with respect to the image forming unit along the sheet conveying direction and configured to detect presence of the sheet in the downstream position with respect to the

upstream-side conveyer, the second sensor being switchable between a presence-detectable state, in which the second sensor detects presence of the sheet, and an absence-detectable state, in which the second sensor detects absence of the sheet; and a controller. The controller is configured to measure presence-detecting duration, which starts when the second sensor is switched from the absence-detectable state to the presence-detectable state and ends when the second sensor is switched from the presence-detectable state to the absence-detectable state; and control the downstream-side conveyer to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between a value calculated based on the measured presence-detecting duration and a reference value obtained based on a reference sheet length of an assumed sheet along the sheet conveying direction is equal to or larger than a predetermined threshold, and to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the value calculated based on the measured presence-detecting duration and the reference value obtained based on the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold.

According to another aspect of the present invention, a sheet conveyer configured to convey a sheet in a predetermined conveyer path along a predetermined sheet conveying direction from an upstream side toward a downstream side, the sheet having a predetermined sheet length along the sheet conveying direction, is provided. The sheet conveyer includes a first sensor arranged along the conveyer path and configured to detect presence and absence of the sheet when the sheet passes by the first sensor, the first sensor being configured to output presence-detectable signals indicating presence of the sheet when presence of the sheet is detected and absence-detectable signals indicating absence of the sheet when absence of the sheet is detected; an upstream-side conveyer arranged along the conveyer path in a downstream position with respect to the first sensor along the sheet conveying direction and configured to convey the sheet having passed by the first sensor toward the downstream side; a downstream-side conveyer arranged along the conveyer path in a downstream position with respect to the upstream-side conveyer along the sheet conveying direction and configured to convey the sheet conveyed by the upstream-side conveyer further toward the downstream side; a second sensor arranged along the conveyer path in a downstream position with respect to the upstream-side conveyer along the sheet conveying direction and configured to detect presence and absence of the sheet when the sheet passes by the second sensor, the second sensor being switchable between a presence-detectable state, in which the second sensor detects presence of the sheet, and an absence-detectable state, in which the second sensor detects absence of the sheet; and a controller. The controller is configured to obtain assumed duration, which is assumed to be required for an assumed sheet having the reference sheet length to be conveyed for a predetermined distance; measure presence-detecting duration, which starts when the second sensor is switched from the absence-detectable state to the presence-detectable state and ends when the second sensor is switched from the presence-detectable state to the absence-detectable state; control the downstream-side conveyer to continue conveying the sheet, if the first sensor is outputting the presence-detectable signals when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the measured presence-detecting duration and the obtained assumed duration is smaller than a predetermined threshold; and control the downstream-side conveyer to stop conveying the sheet if the first sensor is outputting the presence-detectable signals when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the measured presence-detecting duration and the obtained assumed duration is one of greater than and equal to the predetermined threshold.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

FIG. **1** is an illustrative cross-sectional view of a printer according to an embodiment of the present invention.

FIG. **2** is a block diagram to illustrate an electrical configuration of the printer according to the embodiment of the present invention.

FIG. **3** is a diagram to illustrate behaviors of a first sensor and a second sensor while a sheet is inserted and conveyed in the printer according to the embodiment of the present invention.

FIG. **4** is a diagram to illustrate behaviors of the first sensor and the second sensor while a sheet is inserted in and withdrawn from the printer according to the embodiment of the present invention.

FIG. **5** is a diagram to illustrate behaviors of the first sensor and the second sensor while sheets are successively inserted and conveyed in the printer according to the embodiment of the present invention.

FIG. **6** is a diagram to illustrate behaviors of the first and second sensors and registration rollers while the sheet is inserted and conveyed in the printer according to the embodiment of the present invention.

FIG. **7** is a diagram to illustrate behaviors of the first and second sensors and the registration rollers while the sheet is inserted in and withdrawn from the printer according to the embodiment of the present invention.

FIG. **8** is a diagram to illustrate behaviors of the first and second sensors and the registration rollers while the sheets are successively inserted and conveyed in the printer according to the embodiment of the present invention.

FIG. **9** is a flowchart to illustrate a sequence of judgment making in the printer according to the embodiment of the present invention.

FIG. **10** is a flowchart to illustrate S**100** in the judgment making to be executed in the printer according to the embodiment of the present invention.

FIG. **11** is a cross-sectional view of a sheet conveying device according to a second embodiment of the present invention.

FIG. **12** is a cross-sectional side view of a printer according to a third embodiment of the present invention.

DETAILED DESCRIPTION

Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

1. Internal Configuration of Printer

Firstly, an internal configuration of a printer **10** according to a first embodiment will be described with reference to FIG. **1**. The printer **10** according to the embodiment of the present invention is a direct tandem-typed color LED printer, which forms colored images by layering images in multiple colors (e.g., black, yellow, magenta, and cyan) on a sheet **5** being conveyed. In the printer **10**, in a section between a merging

point G and a fixing unit **50**, the sheet **5** is conveyed to flow from a left-hand side toward a right-hand side in FIG. **1**. Therefore, the left-hand side in FIG. **1** may be referred to as an upstream side for the sheet **5** being conveyed, and the right-hand side in FIG. **1** may be referred to as a downstream side for the sheet **5** being conveyed. The sheet **5** has a sheet length L, which is a dimension of the sheet **5** being conveyed along the sheet conveying direction.

The printer **10** includes a sheet feeder **20**, a sheet conveyer **30**, an image forming unit **40**, the fixing unit **50**, and an ejection unit **60**. Inside the printer **10**, an auto-feed conveyer path P**1**, in which sheets picked up from a tray **21** are guided to be conveyed, and a manual-feed conveyer path P**2**, in which manually inserted sheets are guided to be conveyed, are formed.

In the printer **10** of the present embodiment, the auto-feed conveyer path P**1** and the manual-feed conveyer path P**2** merge into a conveyer path P at the merging point which is in an upstream position with respect to registration rollers **33** along the sheet conveying direction. Outlines of the auto-feed conveyer path P**1**, the manual-feed conveyer path P**2**, and the conveyer path P may be formed by, for example, rollers, which will be described below in detail, guiding members (not shown).

The sheet feeder **20** is disposed in a lower position in the printer **10** to feed the sheets **6** from the tray **21**. The sheet feeder **20** includes the tray **21** to accommodate the sheets **5** and pickup rollers **23** to pick up the sheets **5** from the tray **21**.

The sheet conveyer **30** conveys the sheets **5** fed by the sheet feeder **20** and manually inserted sheets toward the downstream side, on which the image forming unit **40** is disposed. The sheet conveyer **30** includes the auto-feed conveyer path P**1**, the manual-feed conveyer path P**2**, an auxiliary feed roller **31**, the registration rollers **33**, and a conveyer belt **35**.

The registration rollers **33** align the sheets **5** conveyed through the auto-feed conveyer path P**1** and the manual-feed conveyer path P**2** in a correct orientation and forward the sheets **5** to the image forming unit **40**. The conveyer belt **35** conveys the sheets **5** forwarded by the registration rollers **33** through the image forming unit **40** and forwards further toward the fixing unit **25** on the downstream side. Thus, the registration rollers **33** are arranged on the upstream side with respect to the conveyer belt **35**, and the conveyer belt **35** is arranged on the downstream side with respect to the registration rollers **33**.

The image forming unit **40** is a direct tandem image forming unit, which forms a multi-colored image in an electrophotographic method by transferring images in multiple colors of toners in layers directly on the sheet **5** being conveyed. The image forming unit **40** has a photosensitive drum **41**, a charger **43**, a developer roller **45**, and a transfer roller **47** for each colored toner to compose the multi-colored image.

The fixing unit **50** is arranged in a downstream position with respect to the image forming unit **40** along the conveyer path P. The fixing unit **50** fixes the multi-colored image transferred on the sheet P thermally there-onto. The ejection unit **60** includes an ejection tray **61** and ejection rollers **63**. The ejection unit **60** conveys the sheet **5** with the fixed image toward the ejection tray **61** to eject.

The manual-feed conveyer path P**2** is a route, through which a manually-inserted sheet is conveyed to have the image formed thereon. The manual-feed conveyer path **2** is formed on a front side of the printer **10**. The sheet **5** may be fed in the manual-feed conveyer path P**2** through an opening **12**, which is formed on a front face of the printer **10**.

The sheet conveyer **30** further includes a first sensor S**1**, a second sensor S**2**, a third sensor S**3**, and a fourth sensor S**4**.

The first sensor S**1** is arranged along the manual-feed conveyer path P**2** in an upstream position with respect to the registration rollers **33**. When the sheet **5** is in the manual-feed conveyer path P**2**, the first sensor S**1** detects presence of the sheet **5** and outputs "on" signals to indicate the presence, and when no sheet **5** is detected in the manual-feed conveyer path P**2**, i.e., when absence of the sheet **5** from the manual-feed conveyer path P**2** is detected, the first sensor S**1** outputs "off" signals.

The second sensor S**2** is arranged along the conveyer path P in a downstream position with respect to the registration rollers **33** and in an upstream position with respect to the image forming unit **40**. The second sensor S**2** detects the sheet **5** in the downstream area with respect to the registration rollers **33** in the conveyer path P and indicates presence of the sheet **5**. When presence of the sheet **5** in the conveyer path P in the downstream area is detected, the second sensor S**2** outputs "on" signals, and when no sheet **5** is detected in the downstream area in the conveyer path P, i.e., when absence of the sheet **5** from the conveyer path P is detected, the second sensor S**2** outputs "off" signals.

The third sensor S**3** is arranged along the conveyer path P in a downstream position with respect to the fixing unit **50**. The third sensor S**3** detects the sheet **5** in the downstream area with respect to the fixing unit **50** in the conveyer path P and indicates presence of the sheet **5**. The fourth sensor S**4** is arranged along the auto-feed conveyer path P**1** and in a position between the auxiliary feed roller **31** and the registration rollers **33**. The fourth sensor S**4** detects the sheet **5** fed from the tray **21**. When presence of the sheet **5** is detected by the third sensor S**3** or the fourth sensor S**4**, the third sensor S**3** or the fourth sensor S**4** outputs "on" signals respectively, and when absence of the sheet **5** is detected, the third sensor S**3** or the fourth sensor S**4** outputs "off" signals respectively.

According to the present embodiment, a distance L**23** (see FIG. **3**) between the second sensor S**2** and the third sensor S**3** along the conveyer path P is reserved to be greater than a sheet length Lo of the sheet **5**. In the present embodiment, the sheet **5** is assumed to have a standard size "A4", of which length along the sheet conveying direction is 297 mm. In other words, the reference sheet length Lo of the assumed sheet **5** is 297 mm, and the distance L**23** between the second sensor S**2** and the third sensor S**3** is reserved to be at least 297 mm.

2. Electrical Configuration of the Printer

Next, an electrical configuration of the printer **10** will be described with reference to FIG. **2**. The printer **10** includes a controller **80**, an operation unit **91**, a display unit **93**, the image forming unit **40**, a network interface **89**, the first-fourth sensors S**1**-S**4**, a timer **87**, and the sheet conveyer **30**.

The controller **80** includes a central processing unit (CPU) **81**, a read-only memory (ROM) **83**, a random access memory (RAM) **85**, and the timer **87**. The ROM **83** stores various programs to control the printer **10**. The CPU **81** executes calculations according to the programs read from the ROM **83**, stores the results obtained from the calculations in the RAM **85**, and controls behaviors of the components in the printer **10**, including the image forming unit **40** and the sheet conveyer **30**, based on the calculations. The timer **87** is used when the CPU **81** measures timings.

The operation unit **91** includes a plurality of buttons (not shown), and a user's instructions concerning the printing operation may be entered through the buttons. The display unit **93** includes a liquid crystal display and lamps, which can display a configuration screen and indicate condition of the printer **10**. The network interface **89** provides connection to the printer **10** with an information terminal device, such as a personal computer (PC) and a facsimile machine, via a net-

work line NT. Through the network interface **89**, the printer **10** can exchange data with the information terminal device **100**.

3. Manual Sheet Feed

Next, feeding and conveyance of the sheet **5** through the manual-feed conveyer path P**2** will be described with reference to FIGS. **3** and **6**. In FIGS. **3**-**6**, positions of the sheets P are indicated in horizontal thick lines. Before the sheet **5** is fed, i.e., at a timing t**0** in FIGS. **3** and **6**, the first sensor S**1** and the second sensor S**2** output "off" signals, and the registration rollers **33** are inactive. When the user inserts a leading end of a sheet **5** in the manual-feed conveyer path P**2** through the opening **12**, at a timing t**1** (see FIG. **6**), the first sensor S**1** detects the sheet **5** and is switched to output "on" signals. The registration rollers **33** start rotating at a timing t**2** (see FIG. **6**), after a predetermined time period T**1** from t**1**. After a predetermined time period T**2** from t**2**, at timing t**3** (see FIGS. **3** and **6**), the registration rollers **33** are stopped. During the predetermined time period T**2**, as the sheet **5** in the manual-feed conveyer path P**2** forwarded beyond the first sensor S**1** hits the registration rollers **33**, the registration rollers **33** draw the first sheet **5** until the leading end of the first sheet **5** reaches an upstream position with respect to the second sensor S**2**. The rotation of the registration rollers **33** is stopped when the leading end of the first sheet **5** reaches the upstream position with respect to the second sensor S**2**.

While the sheet **5** is drawn by the registration rollers **33** to reach the upstream position with respect to the second sensor S**2**, the second sensor S**2** outputs "off" signals. The timings to draw the sheet **5** by the registration rollers **33** and to stop the sheet **5** at the upstream position with respect to the sensor S**2** are determined based on the signals from the first sensor S**1**.

The registration rollers **33** in the present embodiment serve to convey the sheet **5** and to register the timings of the sheet conveyance when the sheet **5** is fed. Therefore, when the sheet **5** is drawn by the registration rollers **33**, and if print data has been received in the printer **10** from the information terminal device **100** through the network interface **89**, at a timing t**4** (see FIG. **6**), the registration rollers **33** resumes conveying the sheet **5**. When the leading end of the sheet **5** passes by the second sensor S**2**, at a timing t**5** (see FIGS. **3** and **6**), the second sensor S**2** is switched to output "on" signals. Meanwhile, the image forming unit **40** starts forming an image with reference to the timing, at which the second sensor S**2** is switched to "on" state, and prints the image on the sheet **5** being conveyed.

As the sheet **5** is conveyed by the registration rollers **33** and the conveyer belt **35** in the image forming unit **40**, a tail end of the sheet **5** being conveyed passes by the first sensor S**1**, and the sheet **5** exits the detective range of the first sensor S**1**. The first sensor S**1** is switched to output "off" signals at a timing t**6** (see FIG. **6**). Further, at a timing t**7** (see FIGS. **3** and **6**), when the tail end of the sheet **5** being conveyed passes by the second sensor S**2**, the sheet **5** exits the detective range of the second sensor S**2**, and the second sensor S**2** is switched to output "off" signals. Thereafter, at a timing t**8** (see FIG. **6**), the registration rollers **33** are stopped. The image formed on the sheet **5** is thereafter thermally fixed by the fixing unit **50**, and the sheet **5** is ejected by the ejection unit **60** to be released in the ejection tray **61**. Once the rotation of the registration rollers **33** is stopped at the timing t**8**, if a second sheet **5** is correctly inserted in the manual-feed conveyer path P**2** through the opening **12**, from a timing t**1**' (see FIG. **6**), the wave pattern along the timings t**1**-t**8** shown in FIG. **6** is repeated.

A duration T of "on" signals for the second sensor S**2** between the timing t**5**, at which the second sensor S**2** is switched to output "on," and the timing t**7**, at which the second sensor S**2** is switched to output "off," is equivalent to a period between a point, at which the leading end of the sheet **5** with the sheet length L passes by the second sensor S**2**, i.e., when the sheet **5** enters the detective range of the second sensor S**2**, and a point, at which the tail end of the sheet **5** passes by the second sensor S**2**, i.e., when the sheet **5** exits the detective range of the second sensor S**2**. In other words, while the sheet **5** is conveyed by the registration rollers **33** and the conveyer belt **35** at a conveying speed V, the duration T of "on" signals for the second sensor S**2** is equal to the sheet length L divided by the conveying speed V (T=L/V).

4. Withdrawal of the Sheet

Behaviors of the sheet **5** being withdrawn from the manual-feed conveyer path P**2** will be described with reference to FIGS. **4** and **7**. When the sheet **5** inserted in the manual-feed conveyer path P**2** and caught by the registration rollers **33** to be forwarded toward the image forming unit **40**, the second sensor S**2** is switched to output "on" signals. Thereafter, while the tail end of the sheet **5** is still protruding from the opening **12**, the user may pull the tail end of the sheet **5** being inserted outward to withdraw the sheet **5** from the manual-feed conveyer path P**2**. In this regard, while the image fanning unit **40** is to start forming the image with reference to the timing, at which the second sensor S**2** is switched to output "on" signals, the image forming unit **40** may continue to form the image even though the sheet **5** is no longer in the manual-feed conveyer path P**2**. Therefore, in order to avoid such "empty" image forming, when the sheet **5** is withdrawn, it is preferable that the image forming operation by the image forming unit **40** is stopped.

When the sheet **5** is manually inserted, and if print data has been received in the printer **10** from the information terminal device **100**, at a timing t**4** (see FIG. **7**), the registration rollers **33** resume conveying the sheet **5**. When the leading end of the sheet **5** being conveyed passes by the second sensor S**2**, at a timing t**5** (see FIG. **7**), the second sensor S**2** is switched to output "on" signals. If the user starts pulling the sheet **5** outward, at a timing t**9** (see FIGS. **4** and **7**), the leading end of the sheet **5**, which once entered the detective range of the second sensor S**2**, is pulled back toward the upstream side with respect to the second sensor S**2**. Therefore, the second sensor S**2** is switched to output "on" signals. In this regard, at timing t**10** (see FIGS. **4** and **7**), while the leading end of the sheet **5** being pulled is beyond the first sensor S**1** at the downstream side with respect to the first sensor S**1** along the sheet conveying direction, the first sensor S**1** remains outputting "on" signals. When the sheet **5** is pulled further outward, the leading end of the sheet **5** is pulled back in an upstream position with respect to the first sensor S**1**; therefore, at a timing t**12** (see FIGS. **4** and **7**), the first sensor S**1** is switched to output "off" signals as well as the second sensor S**2**.

Thus, when the sheet **5** is correctly inserted in the manual-feed conveyer path P**2**, the first sensor S**1** outputting "on" is switched to output "off", while the second sensor S**2** outputting "on" continues to output "on" at the timing t**6** (FIG. **6**). On the other hand, when the sheet **5** is withdrawn backwards, the second sensor S**2** outputting "on" is switched to output "off", while the first sensor S**1** outputting "on" continues to output "on" at the timing t**10** (FIG. **7**). Therefore, based on the difference in the output signals from the first sensor S**1** and the second sensor S**2**, judgment whether the sheet **5** is correctly inserted or withdrawn can be made. In particular, at the time when the second sensor S**2** outputting "off" is switched output "on," if the first sensor S**1** is outputting "off," it is

determined that the sheet **5** is inserted correctly, and if the first sensor S**2** is outputting "on," it may be determined that the sheet **5** is withdrawn.

5. Successive Insertion of Sheets and Making a Judgment

However, in addition to correct insert of the sheet **5** and withdrawal of the sheet **5**, there may be a case that a user inserts two or more sheets successively in the manual-feed conveyer path P**2**. In particular, the user may insert a first sheet **5**A, and without waiting for a sufficient length of period, a second sheet **5**B in the manual-feed conveyer path P**2** (see FIGS. **5** and **8**). In the case of such successive insert without the sufficient waiting period, the second sheet **5**B may be inserted through the opening **12** to reach the detective range of the first sensor S**1** before the tail end of the first sheet **5**A being conveyed exits the detective range of the first sensor S**1** and before the first sensor S**1** is switched to output "off" at a timing t**13** (FIGS. **5** and **8**). In this regard, the first sensor S**1** is maintained "on" without being switched to "off" after the leading end of the first sheet **5**A passes by the first sensor S**1** at the timing t**1** (FIG. **8**). While, at a timing **14** (FIG. **8**), the second sheet **5**B is held by the user at the position to switch the first sensor S**1** to output "on" signals, when the tail end of the first sheet **5**A being conveyed by the registration rollers **33** toward the image forming unit **40** passes by the second sensor S**2**, at a timing t**7** (FIGS. **5** and **8**), the second sensor S**2** is switched to output "off" signals.

Therefore, when the sheets **5**A, **5**B are inserted successively, as well as the case when the sheet **5** is withdrawn, the first sensor S**1** outputting "on" continues to output "on", and the second sensor S**2** outputting "on" is switched to output "off." In other words, in either case, while the second sensor S**2** outputting "on" is switched to output "off," the first sensor S**1** continues to output "on." Thus, difference between the withdrawal and the successive insertion of the sheets **5** cannot be distinguishably recognized from the behavior of the first and second sensors S**1**, S**2**.

In the case of successive insertion, however, the second sensor S**2** continues to output "on" between the timing t**5** (FIGS. **5** and **8**), when the leading end of the first sheet **5**A being forwarded passes by the second sensor S**2**, and the timing t**7** (FIGS. **5** and **8**), when the tail end of the first sheet **5**A being forwarded passes by the second sensor S**2**. Therefore, upon successive insertion of the sheets **5**A, **5**B, the second sensor S**2** continues to output "on" while the first sheet **5**A is forwarded to enter the detective range of the second sensor S**2**, and the duration T of "on" signals for the second sensor S**2** is equivalent to a length of period corresponding to the sheet length L of the sheet **5**A. On the other hand, when the sheet **5** is withdrawn, the duration T of "on" signals for the second sensor S**2** depends on the timing of withdrawal (see FIG. **7**). The duration T of "on" signals for the second sensor S**2** may be referred to as "presence-detecting duration T" hereinafter. Thus, the presence-detecting duration T differs between the successive insertion of the sheets **5**A, **5**B and the withdrawal of the sheet **5**.

Based on the behaviors of the second sensor S**2**, the sheet length L of the sheet **5** and the presence-detecting duration T of the second sensor S**2** with reference to a conveying speed V to convey the sheet **5** are represented in following formulas.

$$L=T*V \quad \text{Formula 1}$$

$$\Delta=|Lo-L|,\ \Delta<K \quad \text{Formula 2}$$

Based on the formulas, it is determined whether the sheets **5**A, **5**B are being successively inserted or the sheet **5** is being withdrawn by comparing the sheet length L of the currently conveyed sheet **5** obtained from the formulas and the sheet length Lo of the assumed-sized sheet, which is, for example, 297 mm. In particular, when an absolute value of a difference Δ between the sheet length Lo of the assumed-sized sheet and the sheet length L of the currently conveyed sheet **5** obtained from Formula 1 is smaller than a threshold K, while K is greater than zero (K>0), it is determined that it is the sheet **5**B being inserted successively following the preceding sheet **5**A. On the other hand, when the absolute value of the difference Δ is greater than or equal to the threshold K, it is determined that the current sheet **5** is being withdrawn.

If it is determined that the current sheet **5** is being withdrawn, conveyance of the current sheet **5** by the sheet conveyer **30** and image forming by the image forming unit **40** is stopped. On the other hand, if it is determined that it is the sheet **5**B being successively inserted, conveyance of the sheet **5**B by the sheet conveyer **30** and image forming by the image forming unit **40** is maintained.

In the present embodiment, the sheet length Lo of the assumed-sized sheet includes a sheet length L**1**, which is a length of a sheet **5** having been inserted in the manual-feed conveyer path P**2** and conveyed successfully by the registration rollers **33** in previous conveyance, and a sheet length L**2**, which is obtained from the print data to be used with the current sheet **5** in the current conveyance. With the two patterns of sheet lengths L**1**, L**2**, whether the current sheet **5** is the sheet **5**B being inserted successively to the sheet **5**A or the sheet **5** being withdrawn is determined by comparing the sheet length L of the current sheet **5** obtained from the formulas and one of the predetermined sheet lengths L**1**, L**2**.

6. Judging Sequence

A sequence of making a judgment between withdrawal and successive insert of the sheets **5** based on the behaviors of the printer **10** will be described with reference to FIGS. **9** and **10**. The sequence of judging is initiated when the user inserts a current sheet **5** in the manual-feed conveyer path P**2** and when the first sensor. S**1** is switched to output "on" signals.

When the first sensor S**1** detects presence of the current sheet **5** in the manual-feed conveyer path P**2** and is switched to output "on" signals (t**1** in FIGS. **6**-**8**), and after a predetermine time period T**1** (t**2** in FIGS. **6**-**8**), the registration rollers **33** start rotating. The registration rollers **33** continue rotating for the predetermined time period T**2** (t**3** in FIGS. **6**-**8**) to convey the current sheet **5** to the upstream position with respect to the second sensor S**2**. Then, in S**10**, the controller **80** starts conveying the current sheet **5** by rotating the registration rollers **33** (t**4** in FIGS. **6**-**8**) if the print data has been received from the information terminal device **100** through the network interface **89**.

The controller **80** monitors the behavior of the second sensor S**2**, and in S**20**, the controller **80** judges whether the second sensor S**2** outputs "on" signals. When the leading end of the current sheet **5** being forwarded passes by the second sensor S**2**, the second sensor S**2** outputs "on" signals (t**5** in FIGS. **6**-**8**). Based on the output signals from the second sensor S**2**, an affirmative judgment is made in S**20** (S**20**: YES).

In S**25**, the controller **80** activates the timer **87** to measure the presence-detecting duration T of the second sensor S**2** (t**5** in FIGS. **6**-**8**). In S**30**, when the predetermined time period elapsed (S**30**: YES), in S**40**, the controller **80** monitors the behavior of the second sensor S**2** to determine whether the second sensor S**2** outputs "off" signals. The procedure of S**30** is provided in order to wait until the second sensor S**2** is stabilized and avoid erroneous detection due to chattering of the second sensor S**2**.

As the current sheet **5** is conveyed toward the downstream side by the registration rollers **33** and the conveyer belt **35**, the

tail end of the current sheet **5** passes by the second sensor S**2**, and the current sheet **5** exits the detective range of the second sensor S**2**.The second sensor S**2** outputting "on" signals is switched to output "off" signals. The controller **80** detects the output signals from the second sensor S**2** and makes affirmative judgment in S**40** (S**40**: YES). In S**45**, the controller **80** stops the timer **87** to obtain the presence-detecting duration T of the second sensor S**2** (t**7** in FIGS. **6** and **8**, t**10** in FIG. **7**).

In S**50**, the controller **80** monitors the output signals from the first sensor S**1** and judges whether the first sensor S**1** outputs "on" signals.

In this regard, if the current sheet **5** is the second sheet **5**B following the first sheet **5**A, and the second sheet **5**B is correctly inserted after the sufficient length of time, when the tail end of the first sheet **5**A passes by the second sensor S**2** (t**7** in FIGS. **3**, **6**), the second sheet **5**B is not yet inserted in the manual-feed conveyer path P**2**. In this case, the first sensor S**1** outputs "off" signals, and negative judgment is made in S**50** (S**50**: NO). The flow proceeds to S**60**.

In S**60**, the controller **80** stores the presence-detecting duration T of the second sensor S**2** measured through S**25**-S**45** in the RAM **85**. If any presence-detecting duration T from a past operation is in the RAM **85**, the current presence-detecting duration T replaces the older presence-detecting duration.

As the controller **80** monitors the outputs from the first and second sensors S**1**, S**2**, the current sheet **5** is forwarded by the conveyer belt **34** toward further downstream to have an image formed thereon by the image forming unit **40**. The current sheet **5** is further conveyed to and beyond the fixing unit **50** to reach the third sensor S**3**.

In S**70**, the controller **80** monitors the output from the third sensor S**3** and judges whether the third sensor S**3** outputs "on" signals. When the leading end of the current sheet **5** being conveyed passes by the third sensor S**3**, the third sensor S**3** outputs "on" signals. Based on the output signals from the third sensor S**3**, an affirmative judgment is made in S**70** (S**70**: YES). When a predetermined time period elapsed in S**80** (S**80**: YES), in S**90**, the controller **80** monitors the behavior of the third sensor S**3** to determine whether the third sensor S**3** outputs "off" signals. The procedure of S**80** is provided, as well as S**30**, in order to wait until the third sensor S**3** is stabilized and avoid erroneous detection due to chattering of the third sensor S**3**.

When the tail end of the current sheet **5** being forwarded passes by the third sensor S**3**, the third sensor S**3** is switched to output "off" signals, and thereby, an affirmative judgment is made in S**90** (S**90**: YES). The conveyer belt **35** in the sheet conveyer **30**, the fixing unit **50**, and the ejection rollers **63** are driven continuously for a predetermined period, and when the current sheet **5** is ejected by the ejection unit **60** in the ejection tray **61**, the conveyer belt **35**, the fixing unit **50**, and the ejection rollers **63** are stopped.

Meanwhile, if the current sheet **5** is being withdrawn or the current sheet **5** is the second sheet **5**B being successively inserted, as has been mentioned above, the first sensor S**1** stays "on" while the second sensor S**2** is switched from "on" to output "off" signals (t**10** in FIG. **7**, t**7** in FIG. **8**). Therefore, affirmative judgment is made in S**50** (S**50**: YES), and the sequence proceeds to S **100**. In S**100**, the controller **80** judges whether the current sheet **5** is the sheer **5** being withdrawn or the second sheet **5**B being successively inserted based on the presence-detecting duration T of the second sensor S**2**.

The judgment in S**100** is made based on comparison between the sheet length L of the current sheet **5**, which is obtained from the presence-detecting duration T of the second sensor S**2**, and the sheet length L**1** of a previous sheet **5**, which was successfully conveyed through the manual-feed conveyer path P**2** in previous conveyance, or the sheet length L**2**, which is obtained from information included in the current print data. The judgment in S**100** includes S**210**-S**330**, which are in a flowchart shown in FIG. **10**. In the following description, it is assumed that flags A, B are cleared before the flow starts.

In S**210**, it is judged whether the previous conveyance of the previous sheet **5** inserted in the manual-feed conveyer path P**2** has been successfully completed. The judgment may be made by, for example, referring to a history concerning the past conveyance of sheets **5**, and successful conveyance of the previous sheet **5** may be determined if the manually-inserted sheet **5** has exited the detective range of the second sensor S**2** and has been detected by the third sensor S**3**.

If the previous conveyance was successfully completed (S**210**: YES), the flow proceeds to S**220**. In S**220**, the controller **80** obtains the sheet length L**1** of the previously successfully conveyed sheet **5**. The sheet length L**1** of the previously successfully conveyed sheet **5** may be obtained based on the following formula.

$$L1=Tr*V+\alpha \qquad \text{Formula 3}$$

In the above Formula 3, Tr represents the presence-detecting duration T of the second sensor S**2** stored in the RAM **85** in S**60** (see FIG. **9**) in the previous conveying sequence. In other words, Tr represents the presence-detecting duration T of the second sensor S**2** measured with the successfully conveyed sheet **5** in the previous conveyance. V represents the conveying speed of the sheet **5**, and a represents a correction value.

The correction value α corrects an error which may be included in the presence-detecting duration T of the second sensor S**2**. For example, when the second sensor S**2** is an optical sensor including a photo-interrupter and a light blocker, which swings in response to the sheet **5** passing by, a position of the light-blocker when the photo-interrupter is switched on is different from a position of the light-blocker when the photo-interrupter is switched off. While the photo-interrupter is moved from the "on" position to the "off" position, and vice versa, time lags for the transient motion are created. Therefore, the time lags should be compensated by the correction value α.

In S**220**, the sheet length L**1** of the previously conveyed sheet **5** is obtained, and the flow proceeds to S**230**. In S**230**, a flag A is set on, and the flow proceeds to S**240**. If the previous conveyance was not successful (S**210**: NO), S**220** and S**230** are omitted, and the flow proceeds to S**240** without setting the flag A. The flag A is referred to later in order to judge whether the previous conveyance was successfully completed. If the previous conveyance was not completed successfully, the sheet length L**1** cannot be calculated; therefore, S**220** and S**230** are omitted.

In S**240**, it is judged whether the print data from the information terminal device **100** received in the printer **10** includes information concerning the sheet length L**2** for the current sheet **5**. If the information is included (S**240**: YES), the flow proceeds to S**250**. In S**250**, the sheet length L**2** for the current sheet **5** being conveyed is extracted from the print data.

When the sheet length L**2** is extracted, the flow proceeds to S**260**, and the flag B is set on. The flow proceeds to S**270**. If the print data does not include the information concerning the sheet length L**2** (S**240**: NO), S**250** and S**260** are omitted, and the flow proceeds to S**270** without setting the flag B. The flag B is referred to later in order to judge whether the print data included the information concerning the sheet length L**2**.

In S270, the controller 80 calculates the sheet length L of the current sheet 5 based on the presence-detecting duration T of the second sensor S2. The sheet length L is obtained based on the following Formula 4.

$$L=T*V+\alpha \quad \text{Formula 4}$$

In the above equation 4, T represents the presence-detecting duration T for the current sheet 5 in the detective range of the second sensor S2 measured by the timer 87. V represents the conveying speed of the sheet 5, and α represents the correction value.

When the sheet length L of the current sheet 5 is obtained in S270, in S280, the obtained sheet length L is compared with the sheet length L1 or the sheet length L2 in order to determine whether the current sheet 5 is the sheet 5 being withdrawn or the sheet 5B inserted successively to the sheet 5A.

In particular, in S280, the controller 80 judges whether the flag A is set on. If the flag A is set on, that is, if the previous conveyance was successfully completed (S280: YES), in S290, the sheet length L obtained from the presence-detecting duration T for the current sheet 5 is compared with the sheet length L1 of the successfully conveyed sheet 5. Based on the comparison, the controller 80 determines whether the sheet length L of the current sheet 5 is substantially equal to the sheet length L1. In particular, it is judged whether the following condition is met.

$$|L1-L|<K \quad \text{Formula 5}$$

In the above Formula 5, L represents the sheet length of the current sheet 5 obtained based on the presence-detecting duration T. L1 represents the sheet length of the successfully conveyed sheet 5 in the previous conveyance. K represents the threshold, which is an allowance for the sheet lengths L and L I are a same length.

When the condition of Formula 5 is satisfied, i.e., when the absolute value of the difference between the sheet length L1 of the successfully conveyed sheet 5 in the previous conveyance and the sheet length L of the current sheet 5 obtained from the presence-detecting duration T is within an extent of the threshold K (S290: YES), it is determined that the sheet length L of the current sheet 5 is the same as the sheet length L1 of the successfully conveyed sheet 5. In other words, it is determined that the sheet length L of the current sheet 5 is equal to the reference sheet length Lo of the assumed-sized sheet. When the sheet length L of the current sheet 5 is substantially equal to the reference sheet length Lo (S290: YES), in S300, it is determined that the current sheet 5 is the sheet 5B being inserted successively to the previously successfully conveyed sheet 5 being the sheet 5A. Upon judging in S290, a reason to determine that the current sheet 5 is the successively inserted sheet 5B, rather than the sheet 5 being withdrawn, based on the equality with the sheet length L1 of the previously successfully conveyed sheet 5, is that: if two sheets 5 are inserted successively to be used for printing in the printer 10, it is likely that the two sheets 5 are in the same size. In other words, it is unlikely that different-sized two sheets 5 are inserted successively to be used. Thus, in S300, it is determined that the current sheet 5 is the successively inserted sheet 5B.

Meanwhile, in S280, if the flag A is not set on (S280: NO), or in S290, if the condition of the Formula 5 is not satisfied (S290: NO), the flow proceeds to S310. In S310, the controller 80 judges whether the flag B is set on.

If the flag B is set on (S310: YES), in S320, the sheet length L obtained from the presence-detecting duration T is compared with the sheet length L2 extracted from the information contained in the print data. Based on the comparison, the controller 80 determines whether the sheet length L of the current sheet 5 is substantially equal to the sheet length L2. In particular, it is judged whether the following condition is met.

$$|L2-L|<K \quad \text{Formula 6}$$

In the above Formula 6, L represents the sheet length of the current sheet 5 obtained based on the presence-detecting duration T. L2 represents the sheet length obtained from the print data. K represents the threshold, which is an allowance for the sheet lengths L and L2 are a same length.

When the condition of Formula 6 is satisfied, i.e., when the absolute value of the difference between the sheet length L2 obtained from the print data and the sheet length L of the current sheet 5 obtained from the presence-detecting duration T is within an extent of the threshold K (S320: YES), it is determined that the sheet length L of the current sheet 5 is the same as the sheet length L2 extracted from the print data. The flow proceeds to S300, and it is determined that the sheet 5 is the sheet 5B inserted successively to the sheet 5A.

In S320, if the condition of Formula 6 is not satisfied (S320: NO), it is determined that the sheet length L of the current sheet 5 and the sheet length L2 extracted from the print data are not the same. The flow proceeds to S330, and it is determined that the sheet 5 is being withdrawn. In S310, if the flag B is not set (S310: NO), the flow also proceeds to S330, and it is determined that the sheet 5 is being withdrawn.

According to the judging flow described above, when the sheet length L obtained from the presence-detecting duration T equates to one of the sheet length L1 of the successfully conveyed previous sheet 5 and the sheet length L2 contained in the print data, it is judged that the current sheet 5 is the sheet 5B being inserted successively. On the other hand, when the sheet length L of the current sheet 5 equates neither of the sheet length L 1 nor the sheet length L2, it is judged that it is withdrawal of the current sheet 5. The flow completes S100 and proceeds to S105 (FIG. 9).

In S105, the controller 80 judges whether it was determined in S100 that the sheet 5 is being withdrawn. If it was determined that the sheet 5 is being withdrawn (S105: YES), the sequence proceeds to S110, and the controller 80 stops the printer 10. In particular, conveyance of the current sheet 5 by the registration rollers 33 and the conveyer belt 35 is stopped, and image forming by the image forming unit 40 is stopped (t10 in FIG. 4 and t11 in FIG. 7). Thus, empty image forming operation can be prevented from being conducted when no sheet 5 is supplied in the printer 10.

In S105, if the controller 80 judges it was determined in S100 that the current sheet 5 is the sheet 5B being inserted successively (S105: NO), the flow proceeds to S120. In S120, the controller 80 executes a continuous processing, in which conveyance of the preceding sheet 5A by the conveyer belt 35 in the sheet conveyer 30 and image forming by the image forming unit 40 is continued. Accordingly, an image is formed on the preceding sheet 5A, and the preceding sheet 5A is forwarded to the fixing unit 50 and ejected by the ejection unit 60 to be disposed in the ejection tray 61. In S120, further, the controller 80 manipulates the display unit 93 to display an error-indicating message such as "Please place the sheet back in the manual-feed conveyer path" in order to have the successively inserted sheet 5B to be inserted correctly after the sufficient time period.

7. Effects

According to the embodiment described above, withdrawal of the sheet 5 from the manual-feed conveyer path P2 and successive insertion of the sheet 5 in the manual-feed conveyer path P2 can be distinguishably recognized. When

the current sheet **5** is the sheet **5**B inserted successively to the sheet **5**A, conveyance of the sheet **5**A by the sheet conveyer **30** and image forming by the image forming unit **40** is maintained in the continuous processing. Therefore, between the preceding sheet **5**A and the successive sheet **5**B, the image is formed at least on the preceding sheet **5**A. Thus, efficiency in image forming with the manually-inserted sheets **5** can be improved. On the other hand, when the sheet **5** is being withdrawn, image forming in the printer **10** is terminated. Therefore, an empty image fanning operation, with no sheet **5** in the printer **10**, can be prevented.

According to the embodiment, the second sensor S**2** is arranged in the upstream position with respect to the image forming unit **40** along the conveying direction of the sheet **5** (e.g., on the left-hand side in FIG. **1**). Therefore, compared to a configuration, in which the second sensor S**2** is arranged in a downstream position with respect to the image forming unit **40** along the conveying direction, the judgment in S**100** can be made in an earlier stage after conveyance of the sheet **5** starts. Accordingly, when judgment is made that the sheet **5** is being withdrawn, the image forming operation by the image forming unit **40** can be stopped in an earlier stage, and the image forming operation can be prevented from being continued vainly.

According to the embodiment, the image forming operation by the image forming unit **40** is activated with reference to the timing, at which the second sensor S**2** starts outputting "on" signals. In other words, the timing to start the image forming operation depends on the output of the second sensor S**2**. While it is important to start the image forming operation in a correct timing, a sensitive sensor is required for the second sensor S**2**. According to the present embodiment, the sheet length L of the sheet **5** is calculated based on the presence-detecting duration T obtained by the sensitive second sensor S**2**. Therefore, an accurate sheet length L can be obtained, and it can be accurately judged whether the sheet length L of the sheet **5** obtained based on the presence-detecting duration T equates to the sheet length L**1** or the sheet length L**2**.

According to the embodiment, the distance L**23** (FIG. **3**) between the second sensor S**2** and the third sensor S**3** is greater than the reference sheet length Lo of the assumed-sized sheet. If the distance L**23** is greater than the reference sheet length Lo, as it is in the embodiment described above, and when the sheet **5** being forwarded passes by the second sensor S**2**, the third sensor S**3** outputs "off" signals. Therefore, the judgment, whether the sheet **5** is being withdrawn or is inserted successively to the previous sheet, cannot be made based on the outputs of the third sensor S**3**. Meanwhile, in the present embodiment, even with the distance L**23** between the second sensor S**2** and the third sensor S**3** being greater than the reference sheet length Lo of the assumed-sized sheet, the judgment between withdrawal or successive insertion can be distinguishably recognized based on the difference between the sheet length L of the currently conveyed sheet **5** and the sheet length Lo of the assumed-sized sheet calculated from the presence-detecting duration T of the second sensor.

According to the embodiment, the sheet length L**1**, which is the length of the sheet **5** inserted in the manual-feed conveyer path P**2** and conveyed successfully by the registration rollers **33** previously, and the sheet length L**2**, which is obtained from currently usable print data, are prepared for the reference sheet length Lo. Based on the sheet length L**2**, which is extracted from the print data, the sheet length L of the current sheet **5** can be assumed effectively. Meanwhile, based on the sheet length L**1** of the successfully conveyed previous sheet **5**, the sheet **5** being currently conveyed is provided with the reference sheet length Lo even when no information concerning the sheet length L**2** is contained in the print data or when the sheet length L**2** contained in the print data is different from the sheet length L of the current sheet **5**.

Second Embodiment

Next, a second embodiment according to the invention will be described. It is noted in the first embodiment that the presence-detecting duration T of the second sensor S**2** is converted into the sheet length L of the current sheet **5**, and the obtained sheet length L is compared with the reference sheet length L**1** or L**2** in order to judge whether the sheet **5** is being withdrawn or being inserted successively to the previous sheet **5**. However, the judgment may not necessarily be based on the converted sheet length L. In the second embodiment, the judgment is made based on comparison between the presence-detecting duration T of the second sensor S**2** and a predetermined prospective presence-detectable duration To.

In particular, the prospective presence-detectable duration To, which is assumed based on the sheet length Lo of the assumed-sized sheet to be conveyed, is obtained from a following Formula 7.

$$To=Lo/V \quad \text{Formula 7}$$

$$\Delta=|To-T|,\ \Delta<K \quad \text{Formula 8}$$

Based on the formulas, it is determined that the sheet **5** is the sheet **5**B inserted successively to the sheet **5**A when an absolute value of a difference Δ between the measured presence-detecting duration T and the prospective presence-detectable duration To is smaller than the threshold K, while K is greater than zero (K>0). On the other hand, when the absolute value of the difference Δ is greater than or equal to the threshold K, it is determined that the sheet **5** is being withdrawn.

More Examples

Although examples of carrying out the invention have been described, those skilled in the art will appreciate that there are numerous variations and permutations of the printer or the sheet conveyer that fall within the spirit and scope of the invention as set forth in the appended claims. It is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or act described above. Rather, the specific features and acts described above are disclosed as example fauns of implementing the claims.

For example, in the above embodiments, the registration rollers **33** serve to convey the sheet **5** and to register the timings of the sheet conveyance when the sheet **5** is manually inserted. However, the printer **10** may not necessarily be configured to have the registration rollers **33** or other components as described in the above embodiments. For example, as shown in FIG. **11**, the two functions of the registration rollers **33** may be separately assigned to conveying rollers **33**A, for conveying the sheet **5**, and registering rollers **33**B, for registering the timing Further, the second sensors S**2** may be arranged in a downstream position with respect to the conveying rollers **33**A. In other words, the second sensor S**2** may not necessarily be arranged in the downstream position with respect to the registering rollers **33**B as long as the second sensor S**2** is arranged in a downstream position with respect to a conveying member (e.g., the rollers **33**A in FIG. **11**), which forwards the sheet **5** having passed by the first sensor S**1**.

For another example, the present invention may not necessarily be applied to the direct tandem-typed color laser printer **10**, which transfers multi-colored developer agents directly onto the sheet **5** being conveyed. The present invention may be similarly effectively applied to other image forming appa-

ratuses, such as an intermediate transfer-typed color laser printer **200** (FIG. **12**), which transfers multi-colored developer agents indirectly onto a sheet via an intermediate transfer belt **210**.

In FIG. **12**, it is to be noted that signs **220**, **230** denote conveyer rollers for conveying the sheet inserted through the opening **12** into the manual-feed conveyer path P**2**, and a sign **240** denotes a pickup roller. Further, a sign **250** denotes a registration roller, and a sign **260** denotes a secondary transfer roller for transferring a colored image onto the sheet. In the example shown in FIG. **12**, the first sensor S**1** is arranged along the manual-feed conveyer path P**2**, and the second sensor S**2** is arranged in a position between the pickup roller **240** and the registration roller **250**.

In the embodiments described above, the printer **10** is provided with the controller **80** including the single CPU **81**, the ROM **83**, and the RAM **85**. However, for example, the controller **80** may be equipped with a plurality of CPUs **81**. For another example, the controller **80** may be a combination of the CPU **81** and a hardware circuit such as an ASIC. Further, the controller **80** may be configured with a hardware circuit alone.

In the first embodiment described above, the sheet length L of the sheet **5** obtained from the presence-detecting duration T is compared with the reference sheet length Lo, which includes the sheet length L**1** of the successfully conveyed previous sheet **5** and the sheet length L**2** contained in the print data. However, the sheet length L may not necessarily be compared with the two sheet lengths L**1**, L**2**. The sheet length Lo may not necessarily have two reference lengths but may have a single reference length to be compared with the sheet length L.

What is claimed is:

1. A sheet conveyer, comprising:

a manual-feed conveyer path, in which a sheet is inserted manually and conveyed along a sheet conveying direction;

a first sensor arranged along the manual-feed conveyer path and configured to detect presence of the sheet inserted in the manual-feed conveyer path;

a registration roller configured to align the sheet in a correct orientation and configured to convey the sheet having passed by the first sensor toward a downstream side along the sheet conveying direction;

an image forming unit configured to form an image on the sheet and configured to convey the sheet conveyed by the registration roller further toward the downstream side along the sheet conveying direction;

a second sensor arranged along the manual-feed conveyer path in a downstream position with respect to the registration roller along the sheet conveying direction and configured to detect presence of the sheet in the downstream position with respect to the registration roller, the second sensor being switchable between a presence-detectable state, in which the second sensor detects presence of the sheet, and an absence-detectable state, in which the second sensor detects absence of the sheet; and

a controller configured to:

measure presence-detecting duration of the second sensor, which starts when the second sensor is switched from the absence-detectable state to the presence-detectable state and ends when the second sensor is switched from the presence-detectable state to the absence-detectable state;

calculate a value based on the measured presence-detecting duration of the second sensor;

control the image forming unit to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the value calculated based on the measured presence-detecting duration of the second sensor and a reference value obtained based on a reference sheet length of an assumed sheet along the sheet conveying direction is equal to or larger than a predetermined threshold; and

control the image forming unit to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the value calculated based on the measured presence-detecting duration of the second sensor and the reference value obtained based on the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold.

2. The sheet conveyer according to claim **1**,

wherein the controller is configured to judge that the sheet is being withdrawn if the measured presence-detecting duration of the second sensor is one of greater than and equal to a reference duration corresponding to the reference sheet length of the assumed sheet along the sheet conveying direction.

3. The sheet conveyer according to claim **2**,

wherein the controller is configured to control the image forming unit to stop conveying the sheet when judgment is made that the sheet is being withdrawn.

4. The sheet conveyer according to claim **1**,

wherein the controller is configured to judge that the sheet is being withdrawn if the value calculated based on the measured presence-detecting duration of the second sensor representing a sheet length of the manually inserted sheet is one of greater than and equal to the reference sheet length of the assumed sheet along the sheet conveying direction.

5. The sheet conveyer according to claim **4**,

wherein the sheet length of the manually inserted sheet is calculated based on the measured presence-detecting duration of the second sensor and a conveying speed of the sheet; and

wherein the controller is configured to control the image forming unit to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold; and

wherein the controller is configured to control the image forming unit to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is one of greater than and equal to the predetermined threshold.

6. The sheet conveyer according to claim **5**,

wherein the reference sheet length is a length of a previously conveyed sheet, which was successfully conveyed in a previous conveying operation in the sheet conveyer.

7. The sheet conveyer according to claim 5,
wherein information concerning the reference sheet length is included in print data, which is received from an information terminal device.
8. The sheet conveyer according to claim 1,
wherein a sheet length of the manually inserted sheet is calculated based on the measured presence-detecting duration of the second sensor and a conveying speed of the sheet;
wherein the controller is configured to control the image forming unit to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold; and
wherein the controller is configured to control the image forming unit to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is one of greater than and equal to the predetermined threshold.
9. An image forming apparatus, comprising:
a manual-feed conveyer path, in which a sheet is inserted manually and conveyed along a sheet conveying direction;
a first sensor arranged along the manual-feed conveyer path and configured to detect presence of the sheet inserted in the manual-feed conveyer path;
a registration roller configured to align the sheet in a correct orientation and configured to convey the sheet having passed by the first sensor toward a downstream side along the sheet conveying direction;
a conveying belt configured to convey the sheet conveyed by the registration roller further toward the downstream side along the sheet conveying direction;
an image forming unit configured to form an image on the manually inserted sheet conveyed through the manual-feed conveyer path;
a second sensor arranged along the manual-feed conveyer path in a downstream position with respect to the registration roller and on an upstream position with respect to the image forming unit along the sheet conveying direction and configured to detect presence of the sheet in the downstream position with respect to the registration roller, the second sensor being switchable between a presence-detectable state, in which the second sensor detects presence of the sheet, and an absence-detectable state, in which the second sensor detects absence of the sheet;
a controller configured to:
measure presence-detecting duration of the second sensor, which starts when the second sensor is switched from the absence-detectable state to the presence-detectable state and ends when the second sensor is switched from the presence-detectable state to the absence-detectable state;
calculate a value based on the measured presence-detecting duration of the second sensor;
control the conveying belt to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the value calculated based on the presence-detecting duration of the second sensor and a reference value obtained based on a reference sheet length of an assumed sheet along the sheet conveying direction is equal to or larger than a predetermined threshold; and
control the conveying belt to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the value calculated based on the measured presence-detecting duration of the second sensor and the reference value obtained based on the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold.
10. The image forming apparatus according to claim 9,
wherein the controller is configured to judge that the sheet is being withdrawn if the measured presence-detecting duration of the second sensor is one of greater than and equal to a reference duration corresponding to the reference sheet length of the assumed sheet along the sheet conveying direction.
11. The image forming apparatus according to claim 10,
wherein the controller is configured to control the conveying belt to stop conveying the sheet when judgment is made that the sheet is being withdrawn.
12. The image forming apparatus according to claim 9,
wherein the controller is configured to judge that the sheet is being withdrawn if the value calculated based on the measured presence-detecting duration of the second sensor representing a sheet length of the manually inserted sheet is one of greater than and equal to the reference sheet length of the assumed sheet along the sheet conveying direction.
13. The image forming apparatus according to claim 12,
wherein the sheet length of the manually inserted sheet is calculated based on the measured presence-detecting duration of the second sensor and a conveying speed of the sheet; and
wherein the controller is configured to control the conveying belt to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold; and
wherein the controller is configured to control the conveying belt to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is one of greater than and equal to the predetermined threshold.
14. The image forming apparatus according to claim 13,
wherein information concerning the reference sheet length is included in print data, which is received from an information terminal device.
15. The image forming apparatus according to claim 13,
wherein the reference sheet length is a length of a previously conveyed sheet, which was successfully conveyed in a previous conveying operation in the sheet conveyer.

16. The image forming apparatus according to claim 9,
wherein the controller controls the image forming unit to start forming the image on the sheet based on output results from the second sensor.

17. The image forming apparatus according to claim 16, further comprising:
a third sensor arranged in a downstream position with respect to the image forming unit and configured to detect presence and absence of the sheet being conveyed,
wherein a distance between the second sensor and the third sensor along the sheet conveying direction is greater than the reference sheet length of the assumed sheet.

18. The image forming apparatus according to claim 9,
wherein the image forming unit is a direct tandem-typed image forming unit, which is configured to form a colored image by layering multi-colored images formed in a plurality of colors of developer agents onto the sheet being conveyed.

19. The image forming apparatus according to claim 9,
wherein the image forming unit is an intermediate transfer-typed image forming unit, which is configured to form a colored image by transferring multi-colored images formed on an intermediate transfer member onto the sheet being conveyed.

20. The image forming apparatus according to claim 9,
wherein a sheet length of the manually inserted sheet is calculated based on the measured presence-detecting duration of the second sensor and a conveying speed of the sheet; and
wherein the controller is configured to control the conveying belt to continue conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is smaller than the predetermined threshold; and
wherein the controller is configured to control the conveying belt to stop conveying the sheet if the first sensor is detecting presence of the sheet when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the sheet length of the manually inserted sheet and the reference sheet length of the assumed sheet along the sheet conveying direction is one of greater than and equal to the predetermined threshold.

21. A sheet conveyer configured to convey a sheet in a predetermined conveyer path along a predetermined sheet conveying direction from an upstream side toward a downstream side, the sheet having a predetermined sheet length along the sheet conveying direction, comprising:
a first sensor arranged along the conveyer path and configured to detect presence and absence of the sheet when the sheet passes by the first sensor, the first sensor being configured to output presence-detectable signals indicating presence of the sheet when presence of the sheet is detected and absence-detectable signals indicating absence of the sheet when absence of the sheet is detected;
an upstream-side conveyer arranged along the conveyer path in a downstream position with respect to the first sensor along the sheet conveying direction and configured to convey the sheet having passed by the first sensor toward the downstream side;
a downstream-side conveyer arranged along the conveyer path in a downstream position with respect to the upstream-side conveyer along the sheet conveying direction and configured to convey the sheet conveyed by the upstream-side conveyer further toward the downstream side;
a second sensor arranged along the conveyer path in a downstream position with respect to the upstream-side conveyer along the sheet conveying direction and configured to detect presence and absence of the sheet when the sheet passes by the second sensor, the second sensor being switchable between a presence-detectable state, in which the second sensor detects presence of the sheet, and an absence-detectable state, in which the second sensor detects absence of the sheet; and
a controller configured to:
obtain assumed duration, which is assumed to be required for an assumed sheet having a reference sheet length to be conveyed for a predetermined distance;
measure presence-detecting duration of the second sensor, which starts when the second sensor is switched from the absence-detectable state to the presence-detectable state and ends when the second sensor is switched from the presence-detectable state to the absence-detectable state;
control the downstream-side conveyer to continue conveying the sheet, if the first sensor is outputting the presence-detectable signals when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if a difference between the measured presence-detecting duration of the second sensor and the obtained assumed duration is smaller than a predetermined threshold; and
control the downstream-side conveyer to stop conveying the sheet if the first sensor is outputting the presence-detectable signals when the second sensor is switched from the presence-detectable state to the absence-detectable state, and if the difference between the measured presence-detecting duration of the second sensor and the obtained assumed duration is one of greater than and equal to the predetermined threshold.

22. The sheet conveyer according to claim 21, further comprising:
an image forming unit configured to form an image on the sheet conveyed through the conveyer path,
wherein the second sensor is arranged in an upstream position with respect to the image forming unit along the sheet conveying direction.

23. The sheet conveyer according to claim 22,
wherein the controller controls the image forming unit to start forming the image on the sheet based on output results from the second sensor.

24. The sheet conveyer according to claim 23, further comprising:
a third sensor arranged in a downstream position with respect to the image forming unit and configured to detect presence and absence of the sheet being conveyed,
wherein a distance between the second sensor and the third sensor along the sheet conveying direction is greater than the reference sheet length of the assumed sheet.

25. The sheet conveyer according to claim 22,
wherein the image forming unit is a direct tandem-typed image forming unit, which is configured to form a col-

ored image by layering multi-colored images formed in a plurality of colors of developer agents on the sheet being conveyed.

26. The image forming apparatus according to claim **22**, wherein the image forming unit is an intermediate transfer-typed image forming unit, which is configured to form a colored image by transferring multi-colored images formed on an intermediate transfer member onto the sheet being conveyed.

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